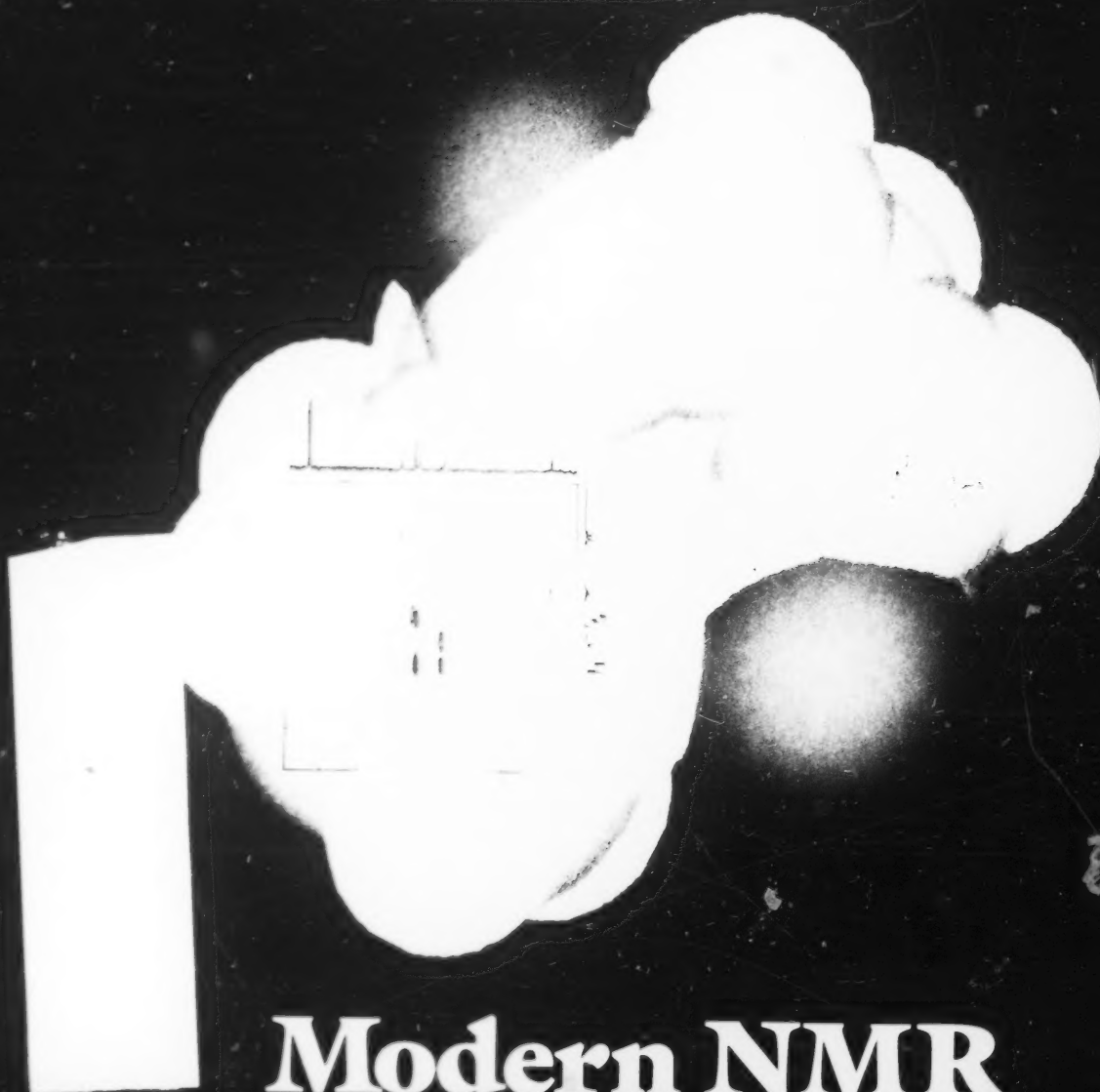


Thermosets' recent growth is slowing
A Key Polymers Review
Page 10

NOVEMBER 5, 1984

CHEMICAL & ENGINEERING

NEWS



Modern NMR Spectroscopy

Biochemical, polymer problems
yielding to new approaches Page 26

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■ No serious health effects can be clearly attributed to chemical waste disposal sites, study finds. **Page 4**

■ Research teams at Princeton and Lawrence Livermore Lab make major advances in development of x-ray lasers. **Page 5**

■ An eleventh-hour agreement may save Montreal's petrochemical industry. **Page 5**

■ OPEC's efforts to limit production likely will have little effect on feedstock prices. **Page 6**

■ C&EN reporter wins Science-in-Society Journalism Award for yellow rain coverage. **Page 6**

■ Research park is established to develop technologies for "basic" industries such as autos, metals, and construction. **Page 6**

Cover: Computer-generated space-filling model of *exo*-tetracyclo[5.5.1.0^{2,6}.0^{10,13}]-tridecane-4,8,12-trione, prepared by Richard J. Feldmann of the National Institutes of Health. The compound's ¹H-¹³C-correlated NMR spectrum obtained at AT&T Bell Laboratories is superimposed

Business

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Congress generous to research in passing funding legislation for 1985; appropriations total more than \$40 million. **Page 20**

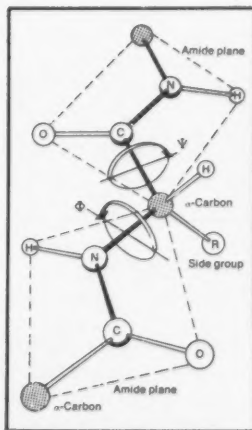
Science

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Cover Story

Important structural information of polymers, as well as natural products, peptide hormones, and proteins, is being obtained from advances in NMR spectroscopy. **Page 26**

Thermoset Plastics: Output On Rise, But Likely To Slow

Production of phenolics, polyesters, and epoxides is forecast to grow into 1985 and then slow, pulling down growth rates to zero to 5%

Bruce F. Greek, C&EN Houston

It's a heady time for producers of three major thermoset plastics—phenolics, polyesters, and epoxies. This year's production of all three resins is running well ahead of 1983 production, and well above recession lows. And prospects are good that these gains will continue into 1985, but at much slower rates.

Producers are braced for the eventuality of a slowdown. For five years after 1978, production of these thermoset resins followed a major dip that left producers with a substantial decline in output. A similar situation could begin in 1985 unless all kinds of construction grow again at the high rates of the 1970s.

Fortunately, as experts see it, the coming dips in resin production won't be as large as they were in the 1980-82 era. But they will pull down average growth rates over the next five years to between zero and 5%.

Analysts have said that describing the thermoset market is like describing the economy, since thermoset resins probably follow the economy as closely as any other chemical product group. The reason is that the big consumers of

duction will cycle from high to low levels and back again. Now that the economy is on the up side, the thermoset cycle also is on the up side, with production achieving new highs that will carry on into the first half of next year.

A shift in demand to a big non-durable use such as packaging—an end use that helps polyethylene avoid violent swings in demand—doesn't even seem to be in the cards for thermosets, since for most non-durables, price is more important than performance, and performance is thermosets' strong suit. In fact, for most uses, the thermoset plastics are the preferred product for performance reasons.

This apparent lack of new market potential has become another characteristic of thermosets as well as that of many other chemicals. Even epoxies and polyesters, youngsters compared to phenolic resins, are considered mature products.

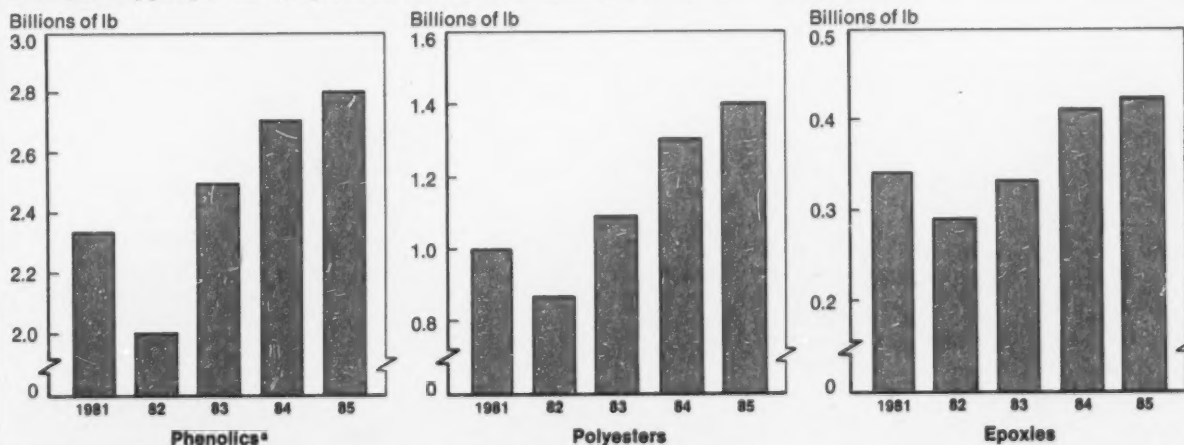
For a more detailed account of the three major thermoset resins, see the following pages.

Key Polymers

thermosets are the highly cyclical construction and durable goods markets that do much to drive the economy. Construction uses more than 50% of thermoset output.

Unless an unlikely situation were to develop in which demand for these resins moved away from durable goods to nondurable goods, pro-

Phenolics, polyesters, epoxies recovered dramatically from recession



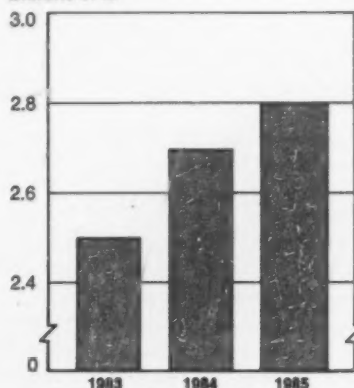
Key Polymers

Phenolics

- **Demand higher**
- **Capacity on hold**
- **Prices down**

PRODUCTION

Billions of lb^a



^a Gross weight, including solvents.

TOP FIVE PRODUCERS

Borden Chemical, Georgia Pacific, Monsanto, Owens-Corning Fiberglas, Reichhold Chemicals

HOW MADE

Reaction of phenol (or substituted phenols) with formaldehyde, subsequently cured by heat or with a crosslinking agent

MAJOR END USES

Plywood adhesives 50%, insulation adhesives 15%, molded items 10%

FOREIGN TRADE

Exports—small, but rising to 30 million to 40 million lb in 1984, imports—negligible

PRICES

List prices vary; bulk of merchant sales in 35 to 45 cents per-lb range

Phenolic resins are topping out another growth spurt. Annual output records for these resins again will be set in 1984 and 1985 unless a serious downturn in the economy occurs within a year. But the rate of growth expected in 1985 will be half that of 1984.

Production of the various types of phenolic resins likely will top 2.7 billion lb in 1984, up at least 8% from 1983 output. That production gain for this year will not be nearly as large as last year's almost 25% gain, when housing recovered from the recession and demand for plywood jumped.

With slowdowns in housing and other construction now appearing, the gain in production of phenolic resins during 1985 will slow to 3 to 5%, unless interest rates rise far more than expected. Thus, 1985 output of these resins could do well to reach 2.8 billion lb. (All estimates of production of phenolic resins are on a gross weight basis that includes solvents and fillers.)

Because so many different kinds of phenolic resins are made by many large and small producers, it is meaningless to estimate capacity to make these resins. Some of the capacity also can be used part time to make other resins, such as alkyds. Likewise, kettles used to make other resins also may be used from time to time to make phenolics.

In general, production of phenolic resins continues to shift toward the large producers. Small consumers who once made their own resins are more likely to buy resins and to scrap their own resin units. Development work on special resins is done mainly by the large producers. This makes them ever more competitive, which tends to force out small producers.

Operating rates for phenolic resins seldom are as good a measure of the health of this segment of the plastics industry. A sizable part of production of phenolic resins is captive, especially that going to make plywood, fiber and granulated-wood boards, and insulation. Many of the small produc-

ers operate their plants only when demand calls for it.

A big part of phenolic resins production, probably more than 75%, eventually ends up in the construction industry, with 50% going into plywood alone. As the construction industry is controlled by the general level of the economy, so is phenolic resin production. The strong upturn in housing that began in 1983 spurred demand for plywood, and phenolic resin production followed. As might be expected, inventory building in plywood surged during the second quarter of 1984 when housing starts topped out. As housing has slowed, along with industrial and other construction, efforts have begun to reduce inventories. This inventory reduction, which is still continuing, is causing production to slow.

In a similar fashion, another large construction use of phenolic resins, insulation, is slowing. Demand for insulation made, for example, of glass fiber bound with phenolic resin as an adhesive actually may be picking up at the retail level, but factory production is slowing because of the lead time. This then slows resin use seasonally. An increase in resin demand for insulation use could occur early in 1985 as producers prepare for the upturn in spring housing construction.

Phenolic molding compounds are the major nonconstruction use of phenolic resins. Good physical properties of strength and heat resistance plus moderate cost keep phenolic resins in long-standing uses in transportation, appliance, and electrical component markets. Growth may be small for phenolic molded items, but competition from other resins seems to be minor, so phenolics producers expect to hold on to these uses.

As one of the oldest synthetic polymers, phenolic resins continue to maintain a growth position, although sometimes erratic. Prospects for increased production are good for all of 1984 and fair in 1985.

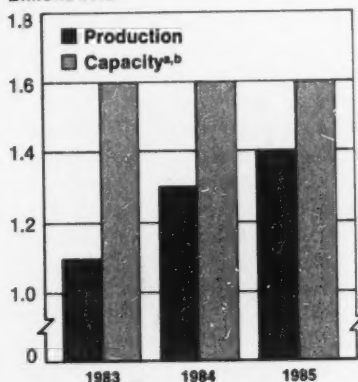
Key Polymers

Polyesters

- **Demand increases**
- **Capacity stable**
- **Prices up slightly**

PRODUCTION/CAPACITY

Billions of lb



a First quarter. b Some capacity may be used for other resins.

TOP FIVE PRODUCERS

Alpha Resin, Ashland Chemical, Koppers, Reichhold Chemicals, USS Chemicals

HOW MADE

Mainly polyesterification of maleic and phthalic anhydrides and propylene glycol

MAJOR END USES

Construction components 30%, boats and marine products 20%, cast products 10%, transportation equipment 10%

FOREIGN TRADE

Exports—tiny, may reach 10 million lb in 1984, imports—negligible

PRICES

List prices range from 50 to 60 cents per lb for major volume types

Production of polyester resins in 1984 will post a strong 20% or more gain over 1983, following a pattern re-established last year. Prospects next year for these resins—more formally called unsaturated polyester resins to distinguish them from other polyester resins used in making fibers, films, and bottles—are about in line with those for many other thermoset plastics. That means output growth of no more than half that expected for 1984.

Production this year likely will total about 1.3 billion lb, up substantially from less than 1.1 billion lb in 1983. This year's production will exceed the previous record production of 1.2 billion lb set back in 1978 and will be a very significant increase from the recent historical low of 850 million lb in 1982. And as long as the economy remains reasonably healthy, the near-term outlook for unsaturated polyester resins will be for a 4 to 6% production gain annually.

Capacity to make unsaturated polyester resins has been on hold for quite some time. As is the case with some other thermoset resins, estimates of plant capacity are not firm. Depending on demand, polyester resin facilities can be used to make other resins. Some small producers readily enter and exit production as they encounter internal or external demand peculiar to their own situations. The types of product resins made also can affect capacity to some degree.

A best-guess estimate for capacity to make polyester resins holds at about 1.6 billion lb a year. This total could be as much as 10% low during times of high demand and 20% high when demand falls drastically, as it did during the early 1980s. Because of relatively simple equipment required for manufacture, capacity additions that go beyond shifting equipment used in making other resins could be made in relatively short times.

For this year and next, capacity utilization for these resins will be quite high if compared to operations of two

years ago. In fact, production could close in on the practical limits of capacity. However, even in 1985 capacity will not be pushed all-out because of the flexibility in getting additional production from other equipment.

The strong production recovery, although it's now slackening some for both economic and seasonal reasons, naturally has helped producer economics. But even though the strong demand has led to some actual increases in selling prices, downward pressure on prices has been applied because of declines in raw material prices, which many consumers expect to be passed on to them.

The production recovery ties in very closely to the economic recovery. Major uses of these resins depend on industries strongly influenced by economic conditions—construction and consumer luxuries such as boats and other recreational items. When these consumption areas feel a recession such as that of the early 1980s, unsaturated polyester resin demand falls precipitously.

With both home and industrial construction now slowing, gains in demand for these resins in such end products as bathroom fixtures and corrosion-resistant tanks will become much smaller next year. Unless another major recession should develop, a decline in demand in these uses seems unlikely.

Generally used with some kind of reinforcing material such as glass fiber to overcome a problem of brittleness, polyester resins go into products that are both cost- and performance-competitive with those made with other materials. For example, polyester-glass fiber composites have almost entirely replaced wood in small boats and now are moving in on aluminum.

A host of other uses, many in the luxury products area, pushes demand for these resins in good times. But this demand quickly melts away during recessions.

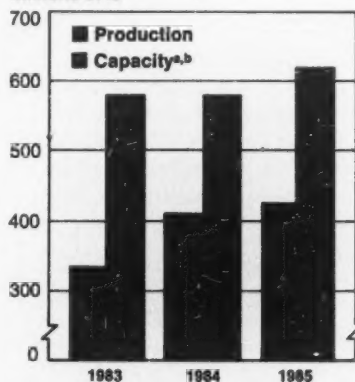
Key Polymers

Epoxies

- **Demand up**
- **Capacity expanded**
- **Prices rising**

PRODUCTION/CAPACITY

Millions of lb



a First quarter. b Liquid and solid unmodified resins.

TOP FIVE PRODUCERS

Celanese Specialty Resins, Ciba-Geigy, Dow Chemical, Reichhold Chemicals, Shell Chemical

HOW MADE

Mainly reaction of bisphenol A and epichlorohydrin; modifications are made later depending on use

MAJOR END USES

Coatings 45%, laminates and composites 25%, castings and molded items 10%

FOREIGN TRADE

Exports—rising to more than 40 million lb in 1984, imports—increasing to more than 10 million lb

PRICES

List prices range from \$1.25 to \$1.40 per lb for large-volume grades

Of the three major-volume thermoset plastics, epoxy resins are setting the best pace this year. Almost all significant end uses are expanding as a result of the better economic climate. But these rosy conditions are tempered by the expectation that the present good times won't last.

Production of the various kinds of epoxy resins in 1984 will be up about 20% to more than 400 million lb, topping the previous production high set in 1979 and finally exceeding the 400 million-lb mark.

While production has been rising, so also has capacity to make epoxy resins. This year Ciba-Geigy completed at mid-year its new plant at McIntosh, Ala., adding about 90 million lb of capacity. Part of the addition is offset, however, by a reduction in capacity at another location.

Capacity might appear to be excessive even with a substantial gain in production this year. But in most cases, capacity estimates are overstated because they include total capacity to make the various forms of the basic epoxy resin. Actual capacities also vary during the year as units may be changed to make different types of resins. Average annual capacity could be as much as 25% less than the total estimated nameplate capacity.

Thus, if production of all kinds of epoxy resins reaches 410 million lb this year, and actual capacity available for production falls somewhere in the range of 425 million to 450 million lb, then capacity utilization would be quite high. Probably a good estimate for the 1984 operating rate would be about 90% of capacity.

The current strong demand for epoxy resins has led to some price rises, both list and actual, during this year. Part of the increases were the usual pass-along price increases for raw materials. However, the increases have been quite modest relative to actual selling prices. Therefore, producers are probably not gaining any real relief in improving their profitability.

In addition, producers are concerned about future prices. If the economy slows in 1985, and demand for epoxy resins slips, then prices might weaken again. One key to holding prices would be a further shift in demand toward the electronic and electrical areas, both of which are growing faster than the old-line coating areas.

Unfortunately, coatings account for nearly half of U.S. epoxy resins consumption. Coatings are dominated by some very large uses—beverage can inside coatings, automotive primers, and industrial maintenance coatings. Each of these major uses, plus some of the smaller uses such as marine and appliance coatings, is heavily dependent on the economy. Some developmental work, particularly in automotive primer systems, could lead to some growth even in a slower economy through capture of markets from other coating materials. Longer term, any increased shift from metal beverage cans to plastic bottles, mostly polyester, could reduce this use, which now accounts for about 20% of epoxy coatings consumption.

Another quarter of epoxy resins consumption goes into various kinds of fiber-reinforced laminates and composites. Most important and fastest growing of these uses is printed circuit boards. This area seems somewhat recession-proof because of growth in demand for various kinds of computer systems, electronic toys, and the like. Although epoxy growth forecasts for these markets vary widely, it generally is forecast at two or three times greater than average growth expected for all epoxy resin uses.

Many other uses of epoxy resins are growing well, but from very small bases. There are so many small uses in this miscellaneous category that they account for more than 10% of total consumption. These uses will help pull along epoxy resin demand, but the near-term growth rate will be 4 to 5% a year because of the huge share of the resins going into various coatings.

European Petrochemical Producers Face More Modest Growth

Next trough may be in 1986, BP executive warns; firms should opt out of weaker lines, concentrate their efforts on smaller number of products

"With improved [chemical company] results in 1983 and 1984, some people already are talking happily of the light at the end of the tunnel," comments Ray R. Knowland, managing director of London-based BP Chemicals International. "My thought is, 'Beware of the headlights of the oncoming train.'"

"Most will agree that we are going through a peak in the chemical cycle. The next trough, perhaps in 1986, is likely to coincide with the arrival on the petrochemical scene of a number of new producers with real competitive advantages. Decisions must be made before the next recession causes financial mayhem for us all. It is vital that we look beyond the immediate prospect and plan for a profitable industry in the 1990s."

In a hard-hitting talk presented to the European Chemical Marketing Research Association's annual meeting held this year in Amsterdam, Knowland urged his fellow West European managers to follow three basic principles. "Forget about the past, think about the future; forget about weaknesses, think about strengths; forget about short-term gains, think about long-term profit," he suggests.

"Lack of lateral thinking is probably the greatest shortcoming of our industry in Western Europe today," he contends. "Some of the important things we should consider when developing a strategy for the

future must include the discarding of outdated ways of thinking no longer relevant to the problems of today. Above all, we must continue to think about consolidation of the industry. But planning is not the whole story. The theory must be put into practice."

The basic strength of petrochemicals is that there are no new substitutes in sight. Consequently, they are not likely to suffer the problems of such basic industries as steel and timber. "Realism dictates, however, that any growth in demand will be modest at best, and slower than in the past," he warns.

In the case of ethylene, a fundamental building block of the petrochemical industry, Knowland anticipates that West European consumption will rise at an average annual rate of 0.8% between 1983 and 1990. On the basis of the 24.3 billion lb-a-year mean average consumption between 1978 and 1983, demand in 1990 likely would rise to about 25.7 billion lb. At that level, however, use would remain well below Western Europe's 1983 effective capacity of 33.2 billion lb.

The underlying growth in consumption of ethylene derivatives in Western Europe is similar to the industrial production index, although growth in ethylene demand is lower. Knowland notes that "this results from an expected decline in net exports with the advent of the new producers [in the Middle East and elsewhere], and, to a lesser extent, lower ethylene usage reflecting, for example, linear low-density polyethylene substituting for LDPE."

The prospect for propylene is more encouraging. Knowland pegs the annual average rate of growth at 2.5% from 1983 to 1990. This would raise demand to about 15.4

billion lb from the 13.0 billion lb-a-year mean of 1978 to 1983. Shortage is unlikely in light of Western Europe's effective output capacity of 18.73 billion lb for the olefin in 1983.

"The better picture for propylene," Knowland points out, "is due to higher growth of polypropylene, and, to a smaller degree, in propylene oxide with no threat from new producers. Propylene derivative growth will be dependent on the availability and price of propylene."

Knowland points up the problem that, compared with the U.S., there are too many producers of individual petrochemicals in Western Europe vying for markets of approximately the same size. In the case of acrylonitrile, for instance, the 10 European makers of the chemical have an average plant capacity of 264 million lb per year, less than half that of the four U.S. producers. More dramatic is the case of propylene oxide, in which the eight European companies in the business have an average annual output capability of

Europe has more, smaller makers of major petrochemicals than U.S.

	Number of producers	Total annual capacity (billions of lb)	Average capacity per producer (millions of lb)
Acrylonitrile			
U.S.	4	2.20	550
Western Europe	10	2.64	264
Low-density polyethylene			
U.S.	11	9.88	880
Western Europe	19	11.88	625
Polypropylene			
U.S.	12	5.28	440
Western Europe	17	5.28	311
Propylene oxide			
U.S.	2	2.86	1430
Western Europe	8	2.20	275

Source: BP Chemicals International

275 million lb, about one fifth that of each of the two corresponding U.S. concerns.

"The U.S. trend has been for companies to opt out of their weaker lines—Arco out of polyolefins, and Ethyl Corp. out of polyvinyl chloride are recent examples. But there are nothing like enough examples in Western Europe," he says.

Admittedly, steps have been taken by European companies to realign their product mix. BP Chemicals itself has shed its PVC activities, for instance. More recently, West Germany's Hoechst decided to lease its LDPE units to Italy's Eni-Chem (C&EN, Aug. 27, page 8). "These precedents need to be followed again and again," Knowland stresses.

"Our target should be to reduce the disparity between us and the U.S. To bring this about must be the objective of our petrochemicals strategy for Europe. The advantages of a wide product portfolio, which could be marketed in groups together, have declined. With finite resources, it is wise after identifying our weaknesses to concentrate

our efforts on a smaller number of products in which we have perceived strengths. To obtain optimum competition, we will need to see some very significant and almost inconceivable rationalization moves."

Nationalism in its many forms is an important competitive disadvantage in Western Europe, Knowland admits. "Unfortunately, politicians discovered years ago that jobs could be saved in the short term by delaying decisions. We now have a situation in which much of the chemical industry within Europe is plugged into politics. The closure of a cracker will lose a few seats in Parliament; therefore, hand out a subsidy has been the reasoning. However, the respite is short lived.

"We must make governments aware that we cannot afford to allow Europe to lag behind its competitors in terms of efficiency. The industry continues to need restructuring. This will occur only if individual companies are rigorous in their analysis of their portfolios, and are prepared to remove weak products as they are identified."

Dermot O'Sullivan, London

Prospects stay dim for European ethylene oxide

One thing ethylene oxide producers in Western Europe have failed to do is make money, contends George Ewart, general manager of Imperial Chemical Industries' chemical products unit. "Unless the industry acts quickly, this difficulty will remain," he told the recent European Chemical Marketing Research Association's meeting in Amsterdam.

By his estimate, European companies have lost a cumulative total of some \$1.5 billion on ethylene oxide and derivatives in the four years 1980-83. The pattern continues, even though 1984 is likely to be a peak year in the production cycle.

Nor is the near-term outlook promising. "A cyclical pattern of demand will persist, and the current trend appears to be downward," he notes. Moreover, he warns, "A revival of U.S. exports is likely in 1986 as U.S. domestic demand falls away."

At first glance, it appears strange

that European ethylene oxide makers are losing money, considering the wide variety of products that the oxide's derivatives—glycol, glycol ethers, ethanolamines, and ethoxylates—go into. Included are adhesives, antifreeze and deicing fluids, detergents, explosives, inks,

A cyclical pattern of demand will persist, and the current trend appears to be downward

polyester fiber, film and bottles, and polyurethane foams.

Ewart lays much of the blame for the poor economics on the companies themselves. "We are living with a legacy of overinvestment invariably justified on the back of an ethylene cracker. Some old plants apparently are being retained because they are a leg for supporting

an olefins complex," he says. Barriers to exiting from the business "are reinforced by political and social considerations."

Last year, he notes, 12 European producers shared a combined nameplate capacity of 4.45 billion lb of the oxide, 2.84 billion lb of glycol. In the case of the oxide, the 3.06 billion lb produced in 1983 was only about half the U.S. output, which also is served by 12 companies. This means that European oxide plants operated on average at 69% of their capacity level.

Europe's 1983 glycol demand of 1.78 billion lb accounted for a mere 63% of installed capacity. Some 48% went into polyesters, 36% to the antifreeze market, and the 16% balance was converted to various derivatives. Although European demand for glycol continues, he foresees a slower pace of annual growth for its outlets in the second half of the decade compared with the first.

An added factor is the prospect of competition from Saudi Arabia. Next year, two glycol units will come on stream there with planned annual output totaling 1.1 billion lb. As much as half that could find its way to Western Europe, Ewart believes.

Looking to 1990, Ewart foresees Western European glycol demand amounting to 1.98 billion lb. Imports might supply 660 million lb of this need—perhaps 550 million lb from the Middle East, and 110 million lb from Eastern Europe, and North and South America. West European output, therefore, would drop to about 1.32 billion lb provided by plants with a combined overall nameplate capacity totaling some 1.56 billion lb. On the basis of this reasoning, European capacity would need to be reduced 1.28 billion lb, down 45% from the current level.

"The European industry has very little time to eliminate capacity surpluses, soften the impact of Middle East glycol, and develop a better-quality business for the late 1980s," he says. He proposes closure of uneconomic ethylene oxide plants, and continuing investment in research and technical effort. "Uncompetitive business should go, and go quickly," he urges.

Dermot O'Sullivan, London

Congress enacts important funding bills

The 98th Congress has passed into history. It started on a high note with the enactment of a plan designed to ensure the solvency of the social security system. It ended in confusion, deadlocked on a number of important issues that now will have to be taken up by the 99th Congress that convenes next Jan. 3.

Both the House and Senate passed legislation overhauling the nation's immigration laws that included limitations on the ability of foreign students to remain in the U.S. after graduation. Both also approved amendments to the Export Administration Act, which ensures that shipment of U.S. products, including technical data, abroad will not harm national security. But despite

numerous meetings, House and Senate conferees could not reach an agreement on either bill.

The House approved a multibillion-dollar expansion of the Superfund used to clean up abandoned hazardous waste sites and a renewal of the Clean Water Act that would have extended cleanup deadlines for industry discharges into waterways and mandated cleanup of toxic "hot spots." The Senate passed neither bill, although both cleared its Environment & Public Works Committee. The water bill, in fact, was cleared for floor action in 1983 but still never came up for a vote. Neither branch passed a renewal of the Clean Air Act even though its funding authorization expired in 1981. The question of what to do

about acid rain proved to be too thorny to deal with in an election year, as did the question of decontrolling natural gas prices.

The 98th Congress did, however, enact a number of important bills, including a major math and science education bill, funded at \$1 billion over two years, designed to help local school districts improve teaching efforts in these areas. It cleared a rewrite of the hazardous waste disposal law that bans most land disposal of liquid hazardous waste and, for the first time, requires generators of small quantities (100 to 1000 kg per month) of hazardous waste to comply with the law. It also passed a bill allowing companies to conduct joint R&D ventures without running afoul of the anti-trust laws as long as certain conditions are met, including informing the Justice Department and the Federal Trade Commission of who the parties in a venture are and what its objective is.

Also enacted during the final days of the 98th Congress was a bill allowing an extension of the life of a patent for products that are regulated by the Food & Drug Administration. In addition, Congress cleared legislation that allows statutory invention recording (otherwise known as a "defensive patent"), combines the Board of Patent Appeals with the Board of Patent Interferences, and sets up a two-year study of the rights of employed inventors.

But most of Congress' attention during its last few weeks was focused on the subject of money. By Oct. 1, the start of the new fiscal year, Congress had cleared only four of the 13 regular appropriations bills. Luckily for the science community, those four bills included fiscal 1985 funding for the National Science Foundation, National Aeronautics & Space Administration, Environmental Protection Agency, and most of the Department of Energy's research programs (C&EN, July 16, page 24).

Those agencies were in the almost unbelievable position of knowing three months ahead of time just how much money they had to spend in fiscal 1985, but the other big research funding agencies, such as the Department of Defense and the Na-

Congress generous to research in omnibus budget bill

\$ Millions	1985		1984	% change 1984-85
	Congressional appropriation	Administration request		
Defense	\$33,332.8	\$36,054.2	\$26,819.6	24%
Tactical programs	11,492.3	12,641.4	7,908.8	45
Strategic programs	8,348.3	8,735.1	7,842.7	6
Intelligence and communications	3,946.6	4,215.6	3,404.4	16
Defensewide mission support	3,600.9	3,814.8	3,235.3	11
Technology base	3,105.0	3,226.3	3,042.2	2
Advanced technology development	2,839.7	3,421.0	1,386.2	105
NIH	5,021.9	4,296.1	4,230.6	19
Cancer	1,183.8	1,077.8	1,083.4	12
Heart, Lung & Blood	805.3	690.8	674.6	19
Arthritis, Diabetes & Digestive & Kidney Disease	543.6	456.2	442.5	23
General Medical Science	482.3	375.4	366.8	31
Neurological & Communicative Disorders & Stroke	396.9	335.1	325.5	22
Allergy & Infectious Diseases	371.0	316.7	305.7	21
Child Health & Human Development	313.3	270.3	265.0	13
Environmental Health Sciences	194.8	173.0	177.8	9
Eye	181.7	154.3	150.8	20
Aging	144.5	114.3	112.3	29
Dental Research	106.7	87.2	84.3	19
Research resources	304.0	245.0	241.9	26
USDA	929.6	865.1	869.9	7
Agricultural Research Service	513.0	483.6	504.0	2
Cooperative State Research Service	284.3	266.8	247.6	15
Forest Service Research	120.9	103.1	108.5	11
National Agricultural Library	11.4	11.6	9.8	16
Interior	455.2	424.5	413.8	10
Geological Survey	412.2	382.3	373.4	10
Fish & Wildlife Service R&D	43.0	42.2	40.4	6
Energy	434.3	342.2	412.9	5
Fossil R&D	299.2	222.6	276.8	8
Conservation R&D	135.1	119.6	136.1	-1
TOTAL	\$40,173.8	\$41,982.1	\$32,746.8	23%

Note: All figures are estimates. Source: Congressional reports

tional Institutes of Health, didn't know how much they had until the day before Congress called it quits on Oct. 12. But the wait was generally worth it.

Funding for DOD's research, development, test, and evaluation activities was set at \$33.3 billion, a 24% increase over fiscal 1984 and a 100% increase over fiscal 1981. The Administration had requested a 26% increase. The Senate Appropriations Committee sounded a warning that the days of large research budget increases may be coming to an end. In its report on the DOD funding bill, it noted that "this is probably the final year that a high level of RDT&E real growth can be sustained in the Congressional budget process."

However, the committee reaffirmed its continuing support for DOD's technology base modernization effort, saying that "increased investment in basic research and innovative technologies is a high RDT&E priority." Thus, the committee said it approved a high level of support for all technology base budget activities and full funding for the university research instrumentation program.

Be that as it may, overall funding for DOD's technology base programs, for which a 6% increase was requested, is up only 2% to \$3.1 billion, whereas funding for advanced technology development has increased more than 100% to \$2.8 billion. Both budget categories provide funding for university-based research. Funding for Air Force RDT&E activities is set at \$13.4 billion, an increase of 10%; the Navy's at \$9.2 billion, up 23%; the Army's at \$4.3 billion, up 2%; and the defense agencies' at \$4.2 billion, up 55%.

Congress was, as always, much more generous than the Administration in funding NIH, handing it a 19% increase to \$5 billion, rather than the requested 1% increase. By some sleight of hand, two of the national institutes—Environmental Health Sciences and Dental Research—emerged from the conference committee on the appropriation bill with more money than was approved by either the House or the Senate. Included in the NIH funding are increases of at least \$25 million for support of an additional

2000 research career awards; \$3.3 million for the minority biomedical research support program; and \$27 million for biomedical research support, of which some \$10 million is to be used for a shared instrumentation program.

Funding for the Department of Agriculture's research programs is set at \$929.6 million, a 7% increase. The Cooperative State Research Service gets the largest increase, 15% to \$284.3 million. Included in that funding is the largest amount ever, \$46 million, for competitive research grants—grants that have, up to now, not been well thought of by the House Appropriations Committee. Biotechnology research grants will account for \$20 million, and plant science research another \$16.5 million.

The Forest Service's research budget, which was slated for a 5% decrease, is up 11% to \$121 million, or \$18 million over the budget request. Over \$5 million of the increase is to be devoted to acid deposition research, and \$8 million is earmarked for a new competitive grants research program. The Agricultural Research Service gets only a 2% increase to \$513 million. That amount includes \$233 million for basic agricultural research and \$384,000 for acid deposition research. And proving that Congress can at times move swiftly, ARS's fiscal 1985 budget includes \$1 million for emergency research on citrus canker. The ARS facility in Orlando gets \$250,000 and the University of Florida \$750,000.

The Department of Energy's fossil R&D budget, which was slated for a 20% decrease, got instead an 8% increase from Congress, and the conservation R&D budget is down only 1% rather than the requested 12%. Included in the conservation budget is \$16 million for establishment of an energy conservation applied research laboratory at Northwestern University. Finally, funding for the research programs at the Department of Interior's Fish & Wildlife Service is set at \$43 million, an increase of 6%, and funding for the Geological Survey's surveys, investigations, and research programs is up 6% to \$412 million.

Janice Long, Washington

Resonances in Electron-Molecule Scattering, van der Waals Complexes, and Reactive Chemical Dynamics



NEW!

Donald G. Truhlar, Editor
University of Minnesota

A unique approach to the growing field of state-selected dynamics. Puts forth photoreactive and collisional resonances as the unifying concept for interpreting a variety of dynamical phenomena. Looks at recent developments in electron-molecule scattering, photoionization, van der Waals complex photodissociation and predissociation, unimolecular dynamics, and state-to-state bimolecular dynamics.

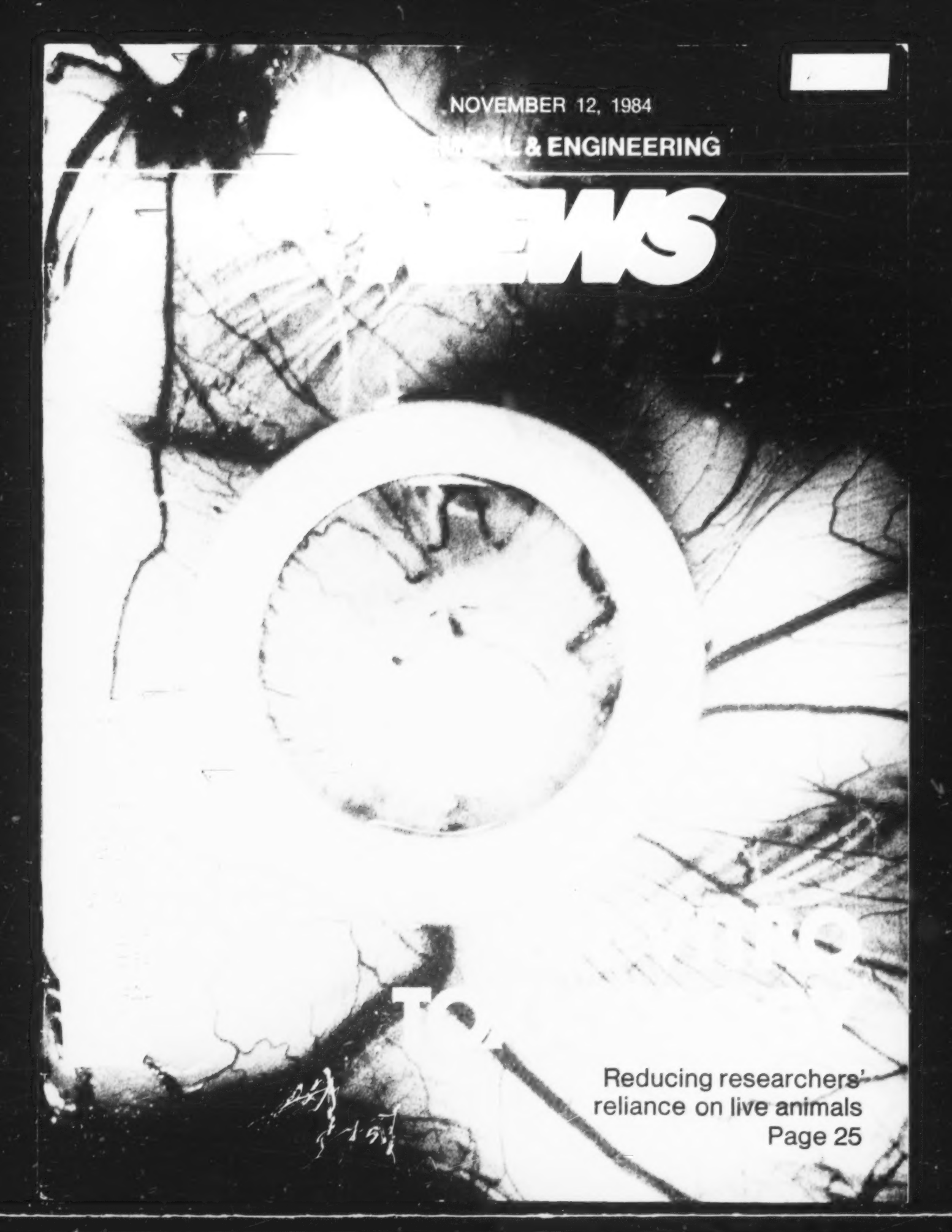
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NOVEMBER 12, 1984

SCIENTIFIC & ENGINEERING

NEWS

TO

Reducing researchers'
reliance on live animals
Page 25

CHEMICAL & ENGINEERING **NEWS**

NOVEMBER 12, 1984

News of the Week

■ Defense R&D expected to gain most from recent elections; smaller gains likely for rest of science and technology research. **Page 4**

■ New injection-molded liquid-crystal polyester resin surpasses most other engineering plastics for strength and resistance. **Page 5**

■ Rumors of acquisition of Allied by United Technologies denied. **Page 5**

■ Atochem of France and ICI of the U.K. negotiate the exchange of various units of their chemicals businesses. **Page 5**

■ Lower natural gas prices in Alberta, Canada, may boost petrochemical exports from that province. **Page 6**

■ Polysilane copolymers sensitive to deep ultraviolet radiation have been developed with an eye toward application as photoresists. **Page 6**

Cover: Chemical applied to portion of chorioallantoic membrane inside Teflon ring causes lesion to form. Research done by Joseph Leighton at Medical College of Pennsylvania, Philadelphia

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Hydrogen peroxide consumption has bounced back from its 1981-82 slump to resume its 7% annual growth rate. **Page 19**

Government

Science and technology policy unit at the General Accounting Office gets new life, more work. **Page 21**

Chemical Information System management passes from the government to private database companies. **Page 22**

Technology

High-octane boosters for gasoline could be made by new catalytic process using natural-gas sources. **Page 29**

Books

"The Apocalypstics: Cancer and the Big Lie" is a critical analysis by Edith Efron of national cancer policies. **Page 31**

ACS News

New ACS Congressional fellow Mark Dickson will join the staff of Rep. Ed Zschau and high-technology task force. **Page 33**



Science

Animals soon may be replaced by tissue cultures in some of the testing done to detect potentially toxic substances. **Page 25**

Chemical Earnings Braked Sharply In Third Quarter

David Webber, C&EN New York

A slowing economy and recalcitrant industrial product pricing reined in the chemical industry's earnings surge in the third quarter of 1984. Composite earnings of the 30 largest U.S. chemical producers increased 16%—not an insubstantial gain—but far less than the great leaps of the previous four consecutive business quarters.

Another sign that the expansion has lost some steam was a great diversity of performance. Most companies' earnings rose, but at sev-

en of the 30 firms, profits actually declined compared to the year-earlier quarter. In the April-to-June 1984 period, by contrast, every company recorded an increase in net income—in most cases, a large one.

This mixed and diminished performance by the chemical industry reflects many developments: the falloff in housing starts, the strength of the dollar overseas, increased import competition, and the regular seasonal slowdown. Also, third-quarter 1983 was the first major recovery quarter for chemical companies following the end of the last

recession. So this year's third-quarter statistics suffer in comparison to the previous year's vitality.

Nonetheless, the relative mediocrity of the industry's composite third-quarter performance has sent analysts back to their drawing boards to devise new, lower earnings forecasts for their clients. At the same time, chief executive officers, though still mostly optimistic about the coming months, concede their firms' vulnerability to weaknesses in the commodity chemical markets—an unfashionable reality in the decade of specialties.

Chemical Industry leaders for the third quarter. . .

Sales			Earnings ^a			Profitability		
Rank	\$ Millions	Rank 1983	\$ Millions	Rank 1983	Earnings as % of sales	Rank 1983		
1 Dow Chemical	\$2829.0	1	Dow Chemical	\$110.0	2	Freeport-McMoRan	10.4%	1
2 Union Carbide	2336.0	2	Monsanto	78.0	1	Loctite	10.3	2
3 W. R. Grace	1858.3	4	Union Carbide	77.0	3	Naico Chemical	10.1	3
4 Monsanto	1599.0	3	PPG Industries	76.7	4	Petrolite	8.9	6
5 PPG Industries	1040.0	5	Hercules	55.9	5	Ethyl	8.4	9
6 American Cyanamid	942.1	6	American Cyanamid	41.9	6	Hercules	8.3	11
7 Celanese	806.0	7	Rohm & Haas	38.8	8	Rohm & Haas	8.0	8
8 Hercules	672.1	8	Celanese	38.0	7	Air Products	7.6	10
9 National Distillers	530.1	11	Ethyl	35.5	9	PPG Industries	7.4	5
10 Morton Thiokol	511.2	10	Morton Thiokol	35.0	10	Lubrizol	7.3	4

. . . and for the first nine months of 1984

Sales			Earnings ^a			Profitability		
Rank	\$ Millions	Rank 1983	\$ Millions	Rank 1983	Earnings as % of sales	Rank 1983		
1 Dow Chemical	\$8731.0	1	Dow Chemical	\$440.0	2	Freeport-McMoRan	11.1%	1
2 Union Carbide	7132.0	2	Monsanto	398.0	1	Loctite	10.9	3
3 Monsanto	5432.0	3	Union Carbide	310.0	3	Naico Chemical	9.9	2
4 W. R. Grace	4897.0	4	PPG Industries	236.9	4	Rohm & Haas	9.3	6
5 PPG Industries	3190.0	5	American Cyanamid	155.8	5	Petrolite	8.6	5
6 American Cyanamid	2880.7	6	Hercules	153.1	7	Lubrizol	8.4	4
7 Celanese	2503.0	7	Rohm & Haas	147.0	6	Air Products	8.1	9
8 Hercules	1954.0	8	W. R. Grace	136.5	8	Hercules	7.8	12
9 National Distillers	1662.7	11	Celanese	129.0	13	First Mississippi	7.6	17
10 Rohm & Haas	1587.5	10	Air Products	106.5	10	Ethyl	7.4	10
						PPG Industries	7.4	10

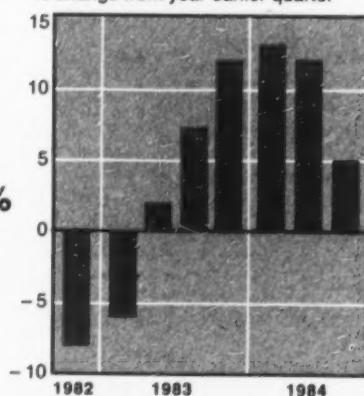
^a After taxes. Note: Based on 30 companies listed on page 14.

Chemical industry 1984 third-quarter results

- Sales up just 5%
- Earnings rise 16%
- Profit margins at 4.7%
- Production climbs 5.6%
- Prices edge up 2.5%

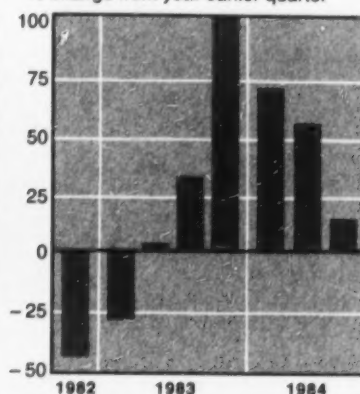
Sales

% change from year-earlier quarter



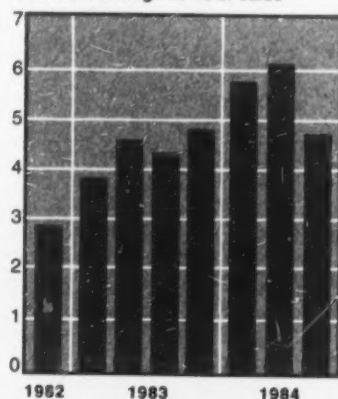
Earnings

% change from year-earlier quarter



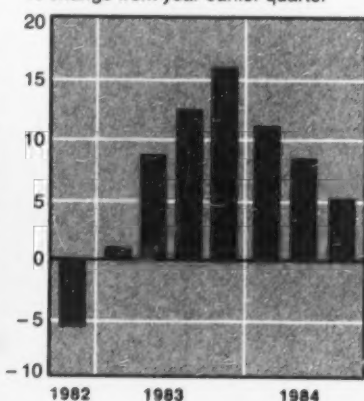
Profit margins

After-tax earnings as % of sales



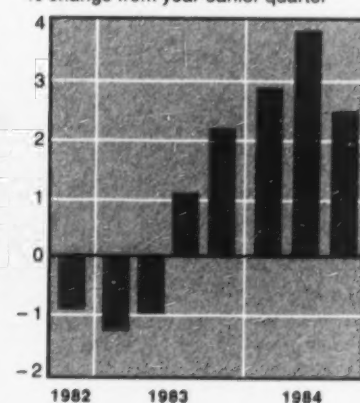
Production

% change from year-earlier quarter



Prices

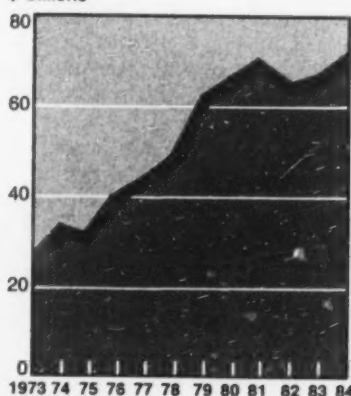
% change from year-earlier quarter



Sales in 1984 will increase 9%, and earnings will rise 40% from last year, sharply boosting profitability

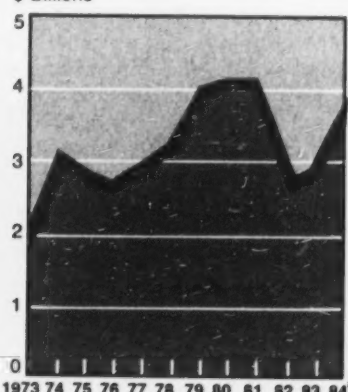
Annual sales

\$ Billions



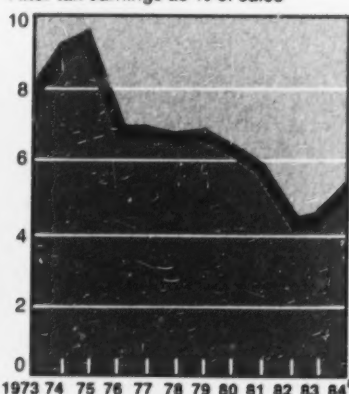
Annual earnings

\$ Billions



Annual profit margins

After-tax earnings as % of sales



* C&EN estimates. Note: All sales, earnings, and profit-margin data are based on combined results of the 30 companies listed on page 14.

Earnings of major chemical companies rose 16% on 5% sales increase

	THIRD-QUARTER 1984						NINE-MONTHS 1984			
	Sales	Earnings ^a	Change from 1983		Profit margin ^b		Sales	Earnings ^a	Change from 1983	
	(\$ millions)		Sales	Earnings	1984	1983	(\$ millions)		Sales	Earnings
Air Products	\$ 418.2	\$ 31.7	2%	16%	7.6%	6.7%	\$ 1,319.2	\$ 106.5	8%	36%
American Cyanamid	942.1	41.9	6	2	4.4	4.6	2,880.7	155.8	10	40
Celanese	809.0	38.0	-1	15	4.7	4.1	2,503.0	129.0	4	115
Chemco	89.0	5.6	32	18	6.3	7.1	256.2	16.6	33	25
Crompton & Knowles	55.2	1.7	-2	42	3.1	2.1	177.6	5.9	3	28
Dow Chemical	2,829.0	110.0	2	28	3.9	3.1	8,731.0	440.0	9	77
Essex Chemical	48.1	1.9	4	146	4.0	1.7	149.2	7.2	12	93
Ethyl	423.3	35.5	-6	18	8.4	6.7	1,287.9	95.7	0	21
First Mississippi	65.9	3.8	14	411	5.7	1.3	223.8	17.0	32	146
Freeport-McMoRan	205.3	21.3	3	-25	10.4	14.6	625.8	69.2	7	-2
H. B. Fuller	114.3	3.6	8	-17	3.1	4.1	336.4	9.3	10	-5
W. R. Grace	1,658.3	33.1	10	18	2.0	1.9	4,807.0	136.5	10	34
Hercules	672.0	55.9	0	28	8.3	6.5	1,954.0	153.1	-2	41
International Flavors	na	na	na	na	na	15.1	na	na	na	na
International Minerals	371.2	23.5	15	14	6.3	6.4	1,229.8	75.5	8	37
Loctite	59.3	6.1	1	-2	10.3	10.5	185.5	20.3	8	25
Lubrizol	205.4	15.0	4	-1	7.3	7.7	836.8	53.6	7	3
Monsanto	1,599.0	78.0	3	-10	4.9	5.6	5,432.0	398.0	17	32
Morton-Thiokol	511.2	35.0	7	18	6.8	6.2	1,575.0	89.9	15	24
Naico Chemical	171.5	17.3	4	2	10.1	10.2	530.5	52.4	8	7
National Distillers	530.1	10.6	12	6	2.0	2.1	1,662.7	58.2	19	56
Olin	497.6	16.3	2	26	3.3	2.7	1,569.4	76.5	8	29
Pennwalt	258.2	12.5	4	-9	4.9	5.6	788.2	33.6	8	25
Petrolite	75.6	6.7	5	26	8.9	7.4	218.7	18.7	1	9
PPG Industries	1,040.0	76.7	12	10	7.4	7.5	3,190.0	236.9	17	44
Reichhold Chemicals	195.9	6.4	1	15	3.2	2.8	624.3	19.8	10	21
Rohm & Haas	464.6	38.8	6	21	8.0	7.0	1,587.5	147.0	10	35
Stauffer Chemical	346.2	4.6	13	def	1.3	def	1,145.9	31.6	19	def
Union Carbide	2,336.0	77.0	3	-4	3.3	3.5	7,132.0	310.0	7	63
Witco Chemical	374.9	15.9	5	14	4.2	3.9	1,124.1	46.8	10	27
Total 15 largest companies	\$15,093.6	\$683.2	4%	19%	4.5%	4.0%	\$46,867.3	\$2,564.8	10%	51%
Second 15 companies	\$ 2,289.9	\$141.3	7%	3%	6.2%	6.4%	\$ 7,107.0	\$ 445.9	10%	17%
GRAND TOTAL	\$17,383.5	\$824.5	5%	16%	4.7%	4.3%	\$53,974.3	\$3,010.7	10%	45%

a Earnings from operations excluding major nonrecurring and extraordinary items. b Earnings as a percentage of sales. na = not available. def = deficit.

The quarter was marked by sluggish financial achievement by many of the largest producers. Union Carbide, for instance, citing the debilities of the steel-related and petrochemical markets, recorded a 4% earnings decline on a 3% increase in sales. Monsanto, feeling the negative aspect of its bottom-line dependence on the company's star product, Roundup, watched the herbicide's third-quarter slump and other factors translate into a 10% drop in net income on a 3% revenue rise. American Cyanamid, noting product launch costs, the negative impact of the dollar's strength, and lower operating earnings from agricultural and chemical products, managed a mere 2% earnings gain

on a 6% rise in sales, after the deletion of nonrecurring items.

Diversified producers with chemical operations also reported smaller gains in the third quarter. With Du Pont, the biggest of a group of 25 such firms, showing a net income gain of just 6% on a sales decline of 2%, the diversified companies had a composite earnings increase of 17% on a sales rise of 5%. For oil and gas companies, the quarter was far worse. Hamstrung by slumping oil prices, 16 energy firms with chemical operations reported a composite 15% drop in earnings on a 1% decline in sales. Still, for many of the energy firms, chemical operations, even with duller growth, accounted for some of the few bright spots.

Despite the loss of gloss, however, the chemical industry is still having an extremely healthy year. Over the first nine months of 1984, composite earnings for the 30 biggest chemical companies increased 45% compared to the same period in 1983. Sales rose 10% over that span. It now appears unlikely, however, that the 50% 12-month rise in net income for 1984 that some forecasters were predicting at the beginning of the year actually will be achieved.

For many chemical producers, pricing has been and remains the most intractable and frustrating obstacle to better margins. In the rosy forecasts for 1984 made a year ago, low feedstock costs were supposed

NINE-MONTHS 1984		12-MONTH RUNNING DATA			
Profit margin ^b		Change from 1983		Profit margin ^b	
1984	1983	Sales	Earnings	1984	1983
8.1%	6.4%	7%	44%	8.1%	6.0%
5.4	4.3	10	46	5.5	4.2
5.2	2.5	7	302	5.4	1.4
6.5	6.9	32	21	6.2	6.7
3.3	2.7	6	33	3.2	2.6
5.0	3.1	10	103	4.3	2.3
4.8	2.8	13	70	4.1	2.7
7.4	6.1	4	21	7.1	6.1
7.6	4.1	31	90	6.8	4.7
11.1	12.1	6	1	11.2	11.8
2.8	3.2	10	12	3.0	2.9
2.8	2.3	10	16	2.7	2.6
7.8	5.5	7	56	7.7	5.3
na	15.6	na	na	na	na
6.1	4.9	9	37	6.7	5.3
10.9	9.4	9	33	10.9	8.9
8.4	8.8	7	17	7.9	7.2
7.3	6.5	11	42	7.0	5.5
5.7	5.3	13	43	6.6	5.2
9.9	10.1	8	12	10.5	10.1
3.5	2.7	26	52	3.2	2.7
4.9	4.1	10	35	4.3	3.5
4.3	3.7	18	48	7.2	5.7
8.6	8.0	10	147	5.4	2.4
7.4	6.1	9	6	7.5	7.7
3.2	2.9	7	48	3.1	2.3
9.3	7.6	11	46	8.9	6.7
2.8	def	12	-431	3.5	def
4.3	2.9	6	72	3.9	2.4
4.2	3.6	12	38	4.2	3.4
5.5%	4.0%	10%	57%	5.2%	3.7%
6.3%	5.9%	10%	33%	6.4%	5.3%
5.6%	4.2%	10%	53%	5.4%	3.9%

to combine with steadily increasing chemical product prices to create very large profits. Instead, much of this year's profitability has come from the continuation of cost controls, modernization programs, and other efforts that have lowered breakeven points around the industry. But now some analysts believe that management at many firms has begun relaxing controls on sales, R&D, and capital expenditures, a trend that would put additional pressure on margins.

It is true that, overall, chemical prices are higher than they were at this time last year. The producers' price index for chemicals and allied products in September was 2.2% above its year-earlier level. But for

the narrower industrial chemicals segment, prices have actually fallen 2.4% over the past 12 months. The drop may be even larger, since the Labor Department cannot track all discounting.

The deleterious effect of weak pricing is cited repeatedly by companies in the comments accompanying their third-quarter income statements. At International Minerals & Chemical, for instance, which recorded a 14% earnings gain, chief executive officer George D. Kennedy says, "We got no help from prices. In fact, prices were lower than expected for every one of our major products." Nor does he expect things to get easier soon.

"There's not been much recovery in most of our markets," he says of the company's fertilizer, animal products, industrial, and gas and oil businesses. "For many of our products, capacity in excess of demand will keep the lid on prices and the pressure on margins. Notwithstanding that, we'll continue to make progress, albeit we'll have to scratch for every inch of it."

At Monsanto, chief executive Richard J. Mahoney explains that gains from profitable silicon operations and strong demand for polymers were offset by weaker industrial chemicals prices, as well as the lower than expected volume of Roundup shipments.

Drummond C. Bell, chairman and chief executive officer of National Distillers & Chemical, says that the company's third-quarter earnings from petrochemical operations, although approximately equal to those of a year earlier, were disappointing and substantially below expectations. Reason: Selling prices of low-density polyethylene weakened steadily throughout the quarter and continued to decline in October, he says. These and other factors kept the company's earnings gain to 6%

Ground rules for C&EN earnings analysis

C&EN's quarterly report on financial performance of the U.S. chemical industry contains data from the 30 largest U.S. basic chemical companies and from 41 diversified companies, each with more than \$200 million in annual chemical sales.

To be included in the table of basic chemical producers, a company must have at least 40% of its sales in chemicals, and its chemical operations must be the largest single portion of the company's operations.

In referring to chemical sales, C&EN means those chemicals whose molecular composition has been changed in the course of manufacture. Hence, chemical sales include those of traditional categories of basic petrochemicals and inorganics, organic intermediates and inorganic compounds, polymers such as plastics and fibers, agricultural chemicals, and specialty derivatives.

In listing earnings, the survey gives after-tax income for continuing operations before nonrecurring items and extraordinary charges. Foreign currency translations are included.

for the quarter, after the deletion of nonrecurring items.

Even Olin, whose 26% increase in net income was one of the strongest in the chemical industry, points out that it was the company's brass operations, not chemical activities, that provided the major boost to earnings. Except for swimming pool chemicals, which performed better than in the previous year, chemicals were problematic.

"While earnings from chemicals were better than in the same period a year ago, prices for several key chemicals, such as chlorine, toluene diisocyanate, and acids, were still below levels that are needed to provide a reasonable return on investment," says John M. Henske, Olin's chief executive officer.

Still, in most cases weak prices were just a constraint on earnings in an essentially upbeat quarter. The composite 16% gain in income represented a slowing in growth, after all, not a reversal. There were posi-

Oil company earnings tumble, but diversified income rises

	% chemical sales	SECOND-QUARTER 1984						NINE-MONTHS 1984					
		Sales (\$ millions)	Earnings ^a	Change from 1983		Profit margin ^b		Sales (\$ millions)	Earnings ^a	Change from 1983		Profit margin ^b	
				Sales	Earnings	1984	1983			Sales	Earnings	1984	1983
OIL AND GAS COMPANIES													
American Petrofina	15%	\$ 567.0	\$ 1.8	0%	-92%	0.3%	4.1%	\$ 1,613.9	\$ 27.8	2%	-13%	1.7%	2.0%
Atlantic Richfield	10	6,038.0	278.0	-2	-34	4.6	6.8	18,650.0	1114.0	1	-4	6.0	6.3
Chevron	4	7,300.0	342.0	-5	-33	4.7	6.6	22,200.0	1100.0	2	-7	5.0	5.5
Exxon	7	23,342.0	1225.0	-1	-4	5.2	5.4	69,928.0	3360.0	-4	-18	4.8	5.6
InterNorth	7	1,742.5	41.6	84	38	2.4	3.2	4,464.4	225.8	35	37	5.1	5.0
Kerr-McGee	13	836.9	21.6	-7	-46	2.6	4.4	2,640.9	99.9	2	-1	3.8	3.9
Mobil	4	15,027.0	238.0	5	-41	1.6	2.8	45,002.0	984.0	5	-7	2.2	2.5
Occidental Petroleum	10	3,914.7	152.9	-20	21	3.9	2.6	11,578.8	384.5	-20	104	3.3	1.3
Phillips Petroleum	16	3,740.0	197.0	-4	12	5.3	4.5	11,750.0	610.0	4	38	5.2	3.9
Shell Oil	16	5,318.0	447.0	4	0	8.4	8.8	15,626.0	1191.0	7	10	7.6	7.4
Standard Oil (Ind.)	10	7,100.0	547.0	-1	-6	7.7	8.1	22,100.0	1665.0	0	18	7.5	6.4
Standard Oil (Ohio)	5	2,933.0	359.0	-2	-17	12.2	14.5	9,139.0	1198.0	3	1	13.1	13.4
Sun Co.	3	3,430.0	122.0	-9	-27	3.6	4.4	11,590.0	402.0	3	3	3.5	3.5
Tenneco	7	3,378.0	126.0	-2	-21	3.7	4.6	11,046.0	501.0	4	5	4.5	4.5
Texaco	4	9,800.0	256.0	-8	-23	2.6	3.1	30,200.0	879.0	-1	-10	2.9	3.2
Unocal (Union Oil)	11	2,890.0	181.2	6	1	6.3	6.6	8,570.0	547.0	7	22	6.4	5.6
DIVERSIFIED MANUFACTURERS													
Allied	23	2,626.0	126.0	5	20	4.8	4.2	8,222.0	389.0	9	25	4.7	4.1
Aluminum Co. of America	11	1,430.0	73.5	3	53	5.1	3.5	4,360.0	284.2	15	316	6.5	1.8
Beatrice	5	2,741.0	82.0	16	-6	3.0	3.7	7,679.0	232.0	10	-4	3.0	3.5
Borden	18	1,139.9	47.9	6	21	4.2	3.7	3,422.7	133.0	11	23	3.9	3.5
Borg-Warner	24	949.0	52.7	6	17	5.6	5.0	2,931.5	149.5	13	19	5.1	4.8
Diamond Shamrock	23	1,130.8	61.6	11	58	5.4	3.8	3,402.9	185.4	19	166	5.4	2.5
Du Pont	43	8,707.0	304.0	-2	6	3.5	3.2	27,078.0	1114.0	3	47	4.1	2.9
Engelhard	13	619.9	19.2	56	1	3.1	4.8	1,868.7	56.9	15	7	3.0	3.3
FMC	37	813.0	57.1	-3	36	7.0	5.0	2,706.2	164.2	5	46	6.1	4.4
General Electric	17	6,720.0	564.0	3	13	8.4	7.6	19,970.0	1628.0	3	13	8.2	7.5
Georgia-Pacific	11	1,880.0	83.0	10	2667	4.4	0.2	5,334.0	218.0	11	145	4.1	1.8
B. F. Goodrich	44	878.1	17.4	3	23	2.0	1.7	2,600.0	59.7	8	381	2.3	0.5
Kaiser Aluminum	19	827.9	-12.5	33	def	def	def	2,314.0	35.7	32	def	1.5	def
Koppers	34	525.8	25.2	17	68	4.8	3.3	1,336.8	36.4	20	141	2.7	1.4
Eli Lilly	24	712.6	111.7	1	8	15.7	14.7	2,331.3	372.4	2	9	16.0	15.0
3M	15	1,991.0	198.0	11	11	9.9	9.9	5,825.0	566.0	10	12	9.7	9.5
Merck	19	857.9	120.9	8	11	14.1	13.7	2,597.7	377.4	9	9	14.5	14.5
NL Industries	33	352.2	6.1	6	def	1.7	def	1,035.1	11.1	-1	def	1.1	def
Pfizer	11	982.7	132.8	4	21	13.5	11.6	2,888.2	378.6	4	15	13.1	11.8
Tyler	32	244.7	9.7	25	45	4.0	3.4	707.4	30.9	30	128	4.4	2.5
Uniroyal	29	529.0	25.0	4	82	4.7	2.7	1,683.5	72.3	12	96	4.3	2.5
U.S. Steel	6	4,700.0	-95.0	2	def	def	def	14,400.0	189.0	12	def	1.3	def
Upjohn	16	510.7	26.8	7	-28	5.2	7.8	1,655.5	139.4	12	10	8.4	8.5
Vulcan Materials	31	266.9	28.7	14	38	10.8	8.9	728.4	61.0	24	69	8.4	6.1

^a From continuing operations excluding nonrecurring and extraordinary items. ^b Earnings as a percentage of sales. **def** = deficit.

tive aspects of third-quarter performance at many companies, fueling a moderate optimism for the quarters to come.

Air Products & Chemicals, for instance, reported record operating profit by its industrial gases & equipment segment—the firm's largest element—for its fiscal year, which

ended Sept. 30. "We were able to achieve this despite the negative effect of the strong dollar on our operations in Europe," notes Edward Donley, Air Products' chairman.

Sales in Air Products' industrial gases segment rose 13% to \$251 million in the third quarter, and operating income increased 40% to \$54.1

million. These gains offset a 13% decline in operating income for the chemicals segment on essentially flat sales performance. The engineering services group did poorly in the quarter, registering decreases of 36% in sales and 55% in operating income.

American Cyanamid reported bet-

ter sales performance by its medical supplies business, phosphate fertilizers, international pesticide lines, and chemicals. At Dow Chemical, executive vice president and chief financial officer Robert M. Keil says that "basic chemicals and plastics are in a much better position compared to 1983," and notes that "the tremendous growth seen in the global plastics business during the past year has moderated."

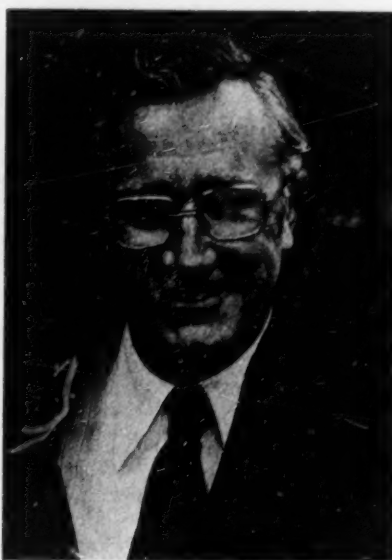
First Mississippi, benefiting from vagaries of the marketplace resulting in higher prices for many of its products, had higher operating profits in both its fertilizer and industrial chemicals operations. W. R. Grace recorded an 18% increase in earnings, thanks primarily to improvement in agricultural chemicals, natural resources, and restaurant operations. Its specialty chemical businesses had lower operating income, on the other hand, on a mixed performance. Though graphic arts, construction products, sealants, and European operations did well, lower earnings by the domestic fluid cracking catalyst business and the deterioration of some Latin American currencies offset gains.

At Hercules, which reported a 28% jump in net income for the quarter, the specialty chemicals business' operating earnings rose 40%. Monsanto says that, despite the unexpected performance by Roundup, it anticipates the herbicide will finish 1984 with higher sales volume than in the previous year.

At Pennwalt, chief executive officer Edwin E. Tuttle says, "Most of our specialty chemical divisions, including the Lucidol division, manufacturer of organic peroxides, continue to do very well. Sales and earnings for agrichemicals also were up for the quarter. In general, the outlook for chemicals remains very positive."

PPG Industries reported sales gains for coatings and resins and chemicals, despite a decline in vinyl chloride sales. Demand increases in the North American automotive and industrial coatings markets gave the coatings and resins segment its boost, and good demand for potash, fertilizers, and chlorine helped the chemicals business.

"Both sales and earnings contin-



Henske: prices still weak

ued to increase from the comparable 1983 quarter," says now-retired chairman L. Stanton Williams, "but the rate of improvement was tempered by moderation in the nation's rate of economic growth."

Stauffer Chemical, which was looking dreadful at this time last year, worked no miracles, but did manage to report a \$4.6 million profit after a \$36.7 million loss in the year-earlier quarter. For the fiscal year (which ended Sept. 30), the company cut operating losses in its agricultural segment to \$4.6 million from \$19.6 million and in its plastics segment to \$12.9 million from \$20.4 million. On the other hand, the chemical segment improved markedly, raising operating income to \$109 million from \$67.0 million in fiscal 1983.

The same pattern of mixed performance marks in the third quarter the results of diversified and energy producers with chemical operations. For instance, among Du Pont's non-Conoco businesses, biomedical products recorded a 4% sales decline and a 20% drop in after-tax operating income. Fibers also suffered: Sales were down 8% and operating income fell 31%. It was a lackluster quarter for agricultural and industrial chemicals, too: Sales and operating income dropped 7% and 12%, respectively. Conversely, polymer products sales and operating profit rose 5% and 55%, respectively.

"Results in July and August reflected the usual summer slowdown in many areas of our business, together with adverse effects on our fibers business of rapidly growing imports of synthetic fibers, fabrics, and apparel," says chairman Edward G. Jefferson. "In September, demand for most product lines improved to the levels achieved in the first half of the year. Margins for refined petroleum products remained weak."

At Allied, net income grew 20% because of solid performance by the automotive and aerospace business lines. The chemical segment, on the other hand, recorded a 1% decline in sales and a 20% decline in after-tax income from continuing operations. Operating profit was higher for industrial fibers, high-density polyethylene, engineered plastics, and hydrofluoric acid. However, the oversupplied soda ash market, decreased demand for carpet fibers, and increased foreign competition in apparel fibers had a greater negative effect on after-tax income.

For most of the energy companies with chemical units, chemical operations provided some of the scarce relief from the woes of the petroleum business. At Standard Oil (Ohio), for example, where overall earnings fell 17% in the third quarter, the chemicals segment had an operating income of \$7 million after a \$6 million loss in the year-earlier quarter.

Shell Oil had an essentially flat quarter overall, but its chemical products segment recorded a 164% boost in operating net to \$37 million. At Mobil, whose total profit tumbled 41%, chemical operations earned \$14 million, 56% more than in the same quarter the year before. Exxon made \$91 million on its chemical operations in the third quarter, 7% more than in the 1983 period, and Atlantic Richfield, which recorded a 34% decline in corporate net income, made \$55 million on its chemicals business, a whopping 206% more than the year before. A rare—for this quarter—disappointing performance by an oil company's chemicals unit was turned in by InterNorth's Northern Petrochemical subsidiary, where earnings fell 16%—mostly because of lower LDPE prices. □

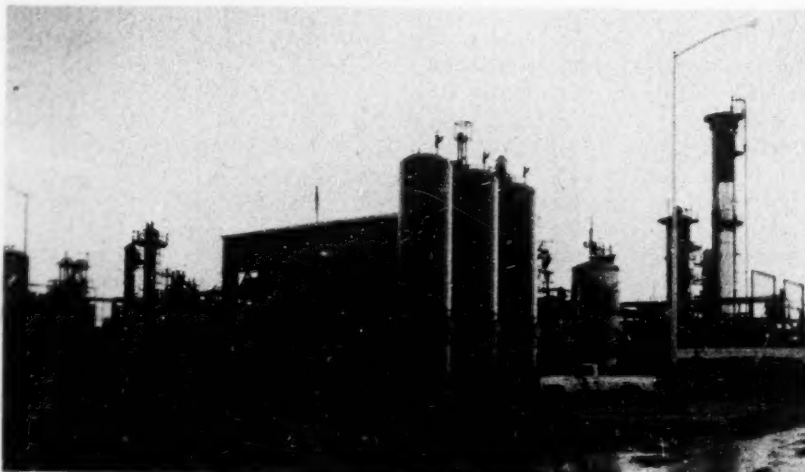
Hydrogen peroxide use resumes steady growth

Demand for hydrogen peroxide has completely recovered from its slump of 1981-82. Shipments have increased enough to keep the average annual compounded growth rate at 7%, the level of the past 30 years. This rate likely will continue for the next five years, says David G. Birney, vice president of marketing for Interlox America, one of three U.S. producers of the peroxide.

Production of hydrogen peroxide will reach 285 million lb in 1984, Interlox forecasts. Current capacity for the peroxide in the U.S. totals about 350 million lb a year. If production comes close to forecasts, the average plant operating rate will be above 80% of nameplate capacity. This level of operating rate approaches the practical limits of capacity utilization, which is 85 to 90% of nameplate. As a result, producers are adding capacity and more distribution facilities.

Latest to expand is Interlox, which will increase capacity of its plant at Deer Park, Tex., 25% to 110 million lb a year. Completion of this expansion is scheduled for June 1985. At the same time, Interlox is increasing by a third its fleet of jumbo tankcars for hydrogen peroxide service.

Late last month, FMC disclosed plans to go ahead with an expansion of its Bayport, Tex., plant in two steps. The first phase, to be on stream in third-quarter 1985, will boost capacity to 85 million lb from



Interlox expansion of its Deer Park, Tex., plant will go on stream by next June

60 million lb. The second phase will add another 10 million lb of capacity in early 1986.

Du Pont has moved to expand its distribution fleet by adding both tank cars and tank trucks. The firm will increase its capacity to deliver hydrogen peroxide about a third.

Use patterns for hydrogen peroxide are changing continually, resulting in part in the strong increase in demand for the oxidizing agent. Pulp and paper manufacture, for instance, has become a fast-rising market. Hydrogen peroxide is getting the nod because it can do the necessary bleaching job at lower cost than chlorine, particularly for mechanical pulping, and because it leaves no chlorine for disposal.

In bleached chemical pulps, such as traditional kraft pulps, demand for hydrogen peroxide is growing because of the construction of new mills, particularly in southeastern U.S., and the modernization of old mills. Use of the peroxide can provide sizable energy savings in the bleaching process. Steam cost, for instance, can be cut \$500,000 a year for a pulp plant with a capacity of about 600 tons per day, according to Interlox's Birney.

The peroxide is finding rising environmental uses. Consumption in both municipal sewage-treating systems and in industrial wastewater treatment is increasing. Because of anticipated stricter laws on treatment of wastes, environmental uses

of hydrogen peroxide could be among the fastest growing over the next few years.

Conversely, use of hydrogen peroxide in chemicals manufacture holds little growth promise because demand for most derivatives has matured. Chemical uses of the peroxide actually declined in the early 1980s, as synthetic glycerine manufacture involving hydrogen peroxide was discontinued. Various inorganic peroxygen compounds account for more than a third of hydrogen peroxide use in chemicals.

Mining, especially the processing of uranium ore, has declined from a major market to a minor part of the "all other" category as a result of the massive slowdown in construction of nuclear power plants and a shift to foreign sources of uranium.

The remaining uses of hydrogen peroxide range over much of the industrial scene and have a mixed outlook. For example, little or no growth is expected from the mature textile bleaching market. The electronics industry is a small market but could have a demand growth rate twice that of the average for hydrogen peroxide. Some very small uses now in the developmental stage could account for very sizable quantities of hydrogen peroxide in five years, Birney points out, just as new and developing uses accounted for a significant share of the volume five years ago.

Bruce Greek, Houston

Hydrogen peroxide at a glance

Production: Estimated at 285 million lb in 1984

Capacity: 350 million lb per year

Producers: Du Pont, FMC, Interlox America (jointly owned by Solvay of Belgium and Laporte Industries of the U.K.)

Markets: Chemical manufacture 25%, pulp and paper 20%, environmental 20%, textile processing 20%, all other 15%

Prices: List ranges between 23 cents per lb for 35% concentration and 45 cents per lb for 70% concentration, freight equalized

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CHEMICAL & ENGINEERING

NEWS

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Organic Electrochemistry
Chemical, engineering, and materials advances
spur new uses Page 43

News of the Week

■ **Presidential commission recommends establishing Cabinet-level Department of Science & Technology.** Page 6

■ **George C. Pimentel will be ACS president-elect in 1985.** Page 7

■ **OTA turns thumbs down on building a permanent manned space station until space program goals are set.** Page 7

■ **COSEPUP panel recommends federal funding for biochemical engineering.** Page 8

■ **Biological properties of chemical compounds from scientists in developing countries will be tested under UN program.** Page 8

Cover: Bank of electrolysis cells, with associated recirculation surge drums, is heart of process Naico Chemical uses for electrosynthesis of lead alkyl antiknock compounds at Freeport, Tex.

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Business

U.S. chemical trade surplus expected to drop 6% below 1983 level, lowest since 1978; U.S. drug firm third-quarter earnings trailed earlier results, partly because of strong U.S. dollar. Page 12

International Business

Anticipated round of multilateral trade negotiations will cover services, investment, high tech, possible tariff cuts. Page 17

Government

Senate committee realignment after selection of a new majority leader may put more liberal Republicans in positions of power; House report blasts EPA's pesticide enforcement record. Page 21

Science

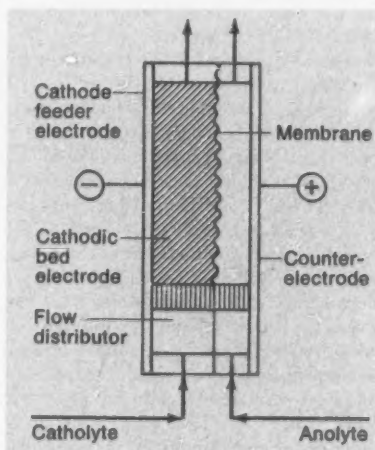
Japan's Suntory Institute for Bioorganic Research is unique in independence from its owner, innovative practices; current work involves structures of natural shark repellents. Page 33

Technology

BP Chemicals International is licensing polyethylene process it claims is low in investment, energy, and labor costs. Page 40

Books

"The Technical Manager's Survival Book" by Melvin Silverman has some helpful guidelines, but little new material. Page 62



Special Report

Organic electrochemistry is undergoing a renaissance catalyzed by new developments in chemistry, engineering, and materials science. Page 43

Chemical Trade Surplus Continues To Shrink

Surplus is forecast to drop this year to almost \$8.5 billion, about 6% below 1983 level and the lowest since 1978

The U.S. international trade deficit in 1984 is easily heading to records that will approach and probably exceed \$100 billion. The relative strength of the dollar, plus the rapidly expanding U.S. economy over the past two years, has provided foreign producers with cheap markets for their products. At the same time, the dollar's strength has made U.S.-produced goods high priced on the foreign markets, while slower growth in foreign economies and some protectionist policies overseas have denied international markets to U.S. producers of goods.

The U.S. chemical industry, one of the few U.S. industries with a positive trade balance, is not im-

mune from these pressures. Although exports have increased for the industry, imports of chemicals into this country have soared even faster, pushing the chemical trade surplus downward.

Through the first nine months of this year, chemical exports have risen 14% to \$16.7 billion. However, at the same time, imports on a customs basis have jumped 31% to \$10.3 billion. [Customs basis is the price actually paid or payable for merchandise when sold for exportation to the U.S.; it excludes such costs as import duties, insurance, and transportation and is essentially the value of the product at the producer's site. Thus it is nearer to being comparable to the export value of product than is the alternative c.i.f. (cost, insurance, freight) value.] The rapid increase of imports into the U.S. has driven the trade surplus downward to the point that, over the first nine months, the balance of trade for the chemical industry has dropped 5% from the comparable period in 1983 to \$6.4 billion.

For the year, C&EN estimates that the trade surplus for chemicals will be almost \$8.5 billion—about 6% below 1983 levels. In spite of the fact that exports will be setting records, this will be the lowest the chemical surplus has been since 1978.

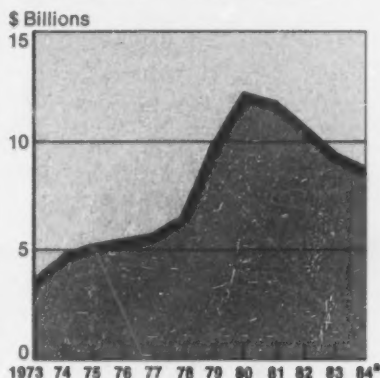
The situation can be regarded as even more dire, however. If the trade surplus is deflated to constant dollars using the producer price index for chemicals, it is projected to amount to about \$2.8 billion (in 1967 dollars) this year, down almost 9% from 1983 and the lowest it has been since the 1960s.

There is a great disparity within the chemical industry itself in terms of the trade balance. According to government figures, for the first five months of 1984, the relative movement of the surplus in chemicals varied widely from product category to product category, depending in no small part on the nature of the chemicals themselves and on government regulation of the products. For instance, the more specialty products and those that must receive government approval for marketing showed less movement in general than did the large commodity-oriented product categories.

Thus, in inorganic chemicals, which have been hard pressed for some time, exports at \$1.09 billion for the first five months remained about the same as the same period last year, whereas imports were rising 20% to \$1.33 billion. This raised the deficit in these chemicals to \$237 million, more than 150 times what it had been in the first five months of 1983.

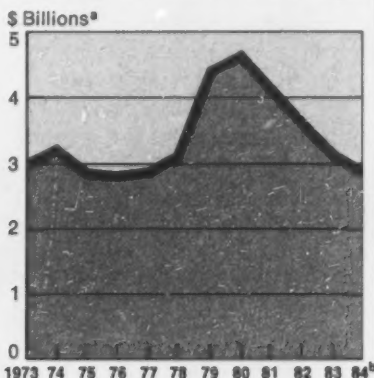
Another big percentage drop was in essential oils and perfume materials, where the surplus fell 47% to \$78.1 million in the first five months of the year. Exports for this small-

Chemical trade surplus has fallen for past four years ...



^a C&EN estimate. Source: Bureau of the Census

... and in constant dollars is lower than a decade ago



^a Deflated by producer price index for chemicals and allied products (1967 = 100). ^b C&EN estimate. Source: Bureau of the Census

Imports of chemicals are soaring

\$ millions	EXPORTS		IMPORTS		TRADE BALANCE	
	First five months 1984	% change from 1983	First five months 1984	% change from 1983	First five months 1984	% change from 1983
Chemicals and related products	\$5921.1	13%	\$5721.2	25%	\$3199.9	-4%
Organic chemicals	2632.8	26	1839.0	29	799.8	19
Inorganic chemicals	1024.6	0	1331.3	20	-236.7	1447
Dyeing, tanning & coloring materials ^a	208.3	5	234.4	35	-26.1	nm
Medicinal & pharmaceutical products	1090.8	4	384.9	34	716.5	-6
Essential oils & perfume materials ^b	359.4	6	261.3	48	78.1	-47
Fertilizer & fertilizer materials	696.6	34	572.0	18	124.6	263
Explosives & pyrotechnic devices	80.5	145	38.8	14	41.7	nm
Synthetic resins & rubber or plastic materials ^c	1627.2	8	615.7	58	1011.5	-9
Other	1190.8	6	470.5	-4	690.3	15

^a Natural and synthetic. ^b Toilet, polishing, and cleansing preparations. ^c Includes waste and scrap. nm = not meaningful. Source: Bureau of the Census.

volume category increased 5% to \$339 million, but imports rose 48% to \$261 million.

Synthetic resins, the second largest volume category, showed a 9% drop in trade surplus to \$1.01 billion on an 8% rise in exports to \$1.63 billion, but an import increase of 56% to \$616 million. Low- and medium-density polyethylene provides an example of what was happening in the synthetic resins area. Low-density polyethylene maintained a healthy positive trade surplus of \$229 million, while exports fell 28% to \$255 million and imports increased more than fivefold to \$25.5 million. Physical volume of the resin through the five-month period increased from 15.6 million lb in 1983 to 76.9 million lb this year, equal to almost 2% of U.S. low-density polyethylene capacity.

Only one of the chemical categories—explosives—recovered from a deficit in 1983 to a surplus this year. Explosive and pyrotechnic devices had a 145% increase in exports to \$80.5 million with only a 14% rise in imports to \$38.8 million. This gave a \$41.7 million surplus in the first five months of this year, compared with a \$1.3 million deficit in the same period in 1983.

Most industry analysts predict that the trade surplus for chemicals will keep dwindling as chemical indus-

tries are built up in other parts of the world. But for the short term, they say that bringing down the federal deficit and lowering the value of the dollar will go a long way to help the current situation. However, not all agree that this is the total answer.

At a recent Chemical Manufacturers Association meeting in Houston, Alfred E. Eckes Jr., chairman of the U.S. International Trade Commission, said, "We should not blithely assume that import competition will go away when the dollar begins to sag. Having penetrated the U.S. market and developed marketing networks and product recognition when the dollar was strong, foreign suppliers will struggle—and accept smaller profits, if necessary—to preserve their market position when the currency advantage diminishes."

Many chemical industry sources do not agree with this assessment, however. One told C&EN that what Eckes says may be true for some smaller, value-added products where foreign producers have found a niche, but for the larger commodity chemicals price is the determining factor and when the price of U.S. goods falls relative to foreign product, customers will quickly switch to take advantage.

William Storck, New York

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Drug company earnings slowed in third quarter

As in the second quarter, one of the most prominent influences affecting pharmaceutical company earnings in the third quarter was the strength of the dollar against overseas currencies. The robust performance of the dollar meant that sales gains in local currency overseas often translated into far smaller gains in dollars. At the same time, companies were faring with differing degrees of success in the newly competitive hospital supply market, leading in some cases to declines in operating earnings in related segments.

These constraints on earnings resulted in a composite gain in net income for a group of 17 major pharmaceutical firms of just 6% on a sales increase of a mere 4% in the third quarter. In the three preceding business periods, by contrast, the industry's net income had registered double-digit percentage increases over the comparative year-earlier quarter. The composite profit margin (after-tax income as a percentage of sales) for the group edged up to 11.1% from 10.9% the year before.

As might be expected, discussion of the impact of currency translation on the bottom line loomed large

in many companies' earnings statement commentaries, and chief executive officers took pains to point out how much better the firm would have done had the dollar's value only stayed where it was 12 months earlier. Exchange rates are vitally important to the pharmaceutical industry, because many companies do as much as a third to a half of their business overseas.

At Avon Products, for instance, the total foreign exchange effect on net earnings was a loss of \$5.2 million in the third quarter and \$18.5 million over the first nine months of 1984. Baxter Travenol, which recorded a 31% decline in net income for the quarter, says that its international sales growth, amounting to 5%, would have totaled 13% had currency values remained constant. At Bristol-Myers, exchange rates cut total company sales growth \$34 million, or 3%, for the quarter, and \$108 million, or 4%, for the nine-month period.

Besieged A. H. Robins, record sales of which were canceled out by litigation costs involving its Dalkon Shield contraceptive device, also felt the exchange rate sting: Net earnings were reduced \$500,000 for the quarter and \$1.8 million for

the first nine months. At SmithKline Beckman, currency translation effects chopped \$17 million and \$54 million, for the quarter and nine-month periods respectively, off total sales. Upjohn's net earnings for the quarter were reduced \$2.4 million by exchange rates.

Hospital cost-containment efforts, spurred by the government's new medicare reimbursement schedule, continue to combine with lower hospital admission rates, resulting in a far more competitive climate for hospital suppliers than was the case even a year ago. At Avon Products' Mallinckrodt division, for example, operating profit declined in the third quarter primarily because of soft demand and weaker prices in several key health-care lines on account of cost-containment programs, the company says. Warner-Lambert chairman Ward S. Hagan says that its health technologies businesses continue to be affected by weakness in the hospital supply market.

Baxter Travenol points out that the company's results continue to be affected negatively by declining hospital admissions in the U.S. "As a result of these factors and the continuing decline of foreign currency values compared to a year ago, the

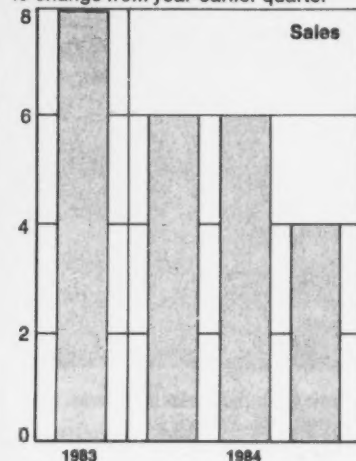
Pharmaceutical firms' earnings rose just 6%, sales 4%

	THIRD-QUARTER 1984						NINE-MONTHS 1984					
	Sales	Earnings ^a	Change from 1983		Profit margin ^b		Sales	Earnings ^a	Change from 1983		Profit margin ^b	
	(\$ millions)		Sales	Earnings	1984	1983	(\$ millions)		Sales	Earnings	1984	1983
Abbott Laboratories	\$ 731.2	\$ 91.4	1%	14%	12.5%	11.1%	\$2253.6	\$279.5	6%	16%	12.4%	11.4%
American Home Products	1191.7	172.5	7	10	14.5	14.0	3450.3	489.7	5	10	14.2	13.5
Avon Products	747.3	30.3	5	13	4.1	3.8	2289.2	108.0	6	5	4.7	4.7
Baxter Travenol	485.9	39.7	-1	-31	8.5	12.2	1340.0	122.6	-2	-23	9.1	11.7
Bristol-Myers	1082.6	133.6	3	14	12.6	11.3	3178.6	354.7	7	17	11.2	10.3
Lilly	712.6	111.7	1	8	15.7	14.7	2331.3	372.4	2	9	16.0	15.0
Merck	857.9	120.9	8	11	14.1	13.7	2597.7	377.4	9	9	14.5	14.5
Pfizer	982.7	132.8	4	21	13.5	11.6	2888.2	378.6	4	15	13.1	11.8
Revlon	617.1	23.4	3	14	3.8	3.4	1759.9	78.8	1	6	4.5	4.3
A. H. Robins	167.3	0.2	9	-99	0.1	10.2	465.7	20.2	11	-54	4.3	10.5
Schering-Plough	464.1	38.3	6	5	8.3	8.4	1426.2	139.5	4	-9	9.8	11.2
G. D. Searle	307.8	44.6	22	12	14.5	15.8	911.5	106.3	38	44	11.9	11.4
SmithKline Beckman	750.8	129.0	-1	-1	17.2	17.1	2183.0	379.7	3	3	17.4	17.4
Squibb	492.8	63.4	7	12	12.9	12.3	1362.3	147.4	5	13	10.8	10.1
Sterling Drug	484.9	45.3	-5	1	9.3	8.7	1388.1	106.1	-2	5	7.6	7.1
Upjohn	510.7	26.8	7	-28	5.2	7.8	1655.5	139.4	12	10	8.4	8.5
Warner-Lambert	798.5	56.6	3	12	7.1	6.5	2373.1	172.7	2	14	7.3	6.5

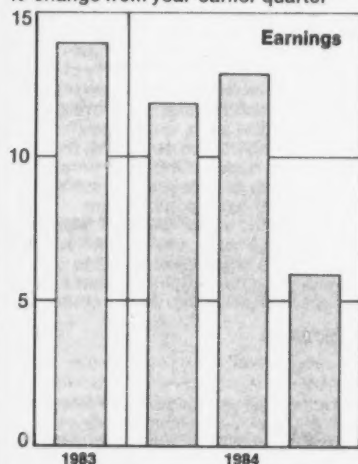
^a Excludes significant extraordinary and nonrecurring items. ^b After-tax income as a percentage of sales.

Pharmaceutical industry 1984 third-quarter results

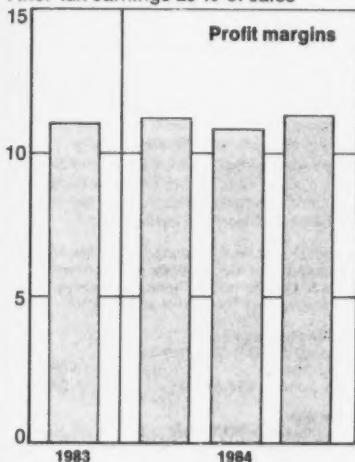
% change from year-earlier quarter



% change from year-earlier quarter



After-tax earnings as % of sales



Note: All sales, earnings, and profit margin data are based on combined results of the 17 companies listed on page 14.



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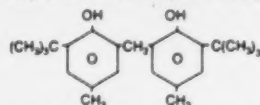
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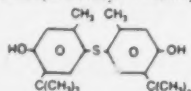
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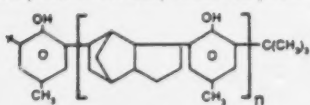
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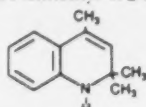
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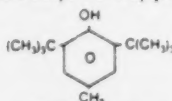
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Business

company does not expect 1984's full-year earnings to exceed those of the previous year," the company says. Over the first nine months of 1984, Baxter Travenol's net income was down 23% from the same period in 1983.

Still, product mix played a major role in how companies performed in the hospital supply market. Abbott Laboratories, for example, with a 14% earnings gain in the third quarter, says that although the company's hospital-related business is being affected by cost containment measures, much of the firm's business does not depend directly on hospital admissions and surgical procedures. Chief executive officer Robert A. Schoellhorn also points out that Abbott's research and development expenditures are up 21% over the first nine months of the year, partly to fund the company's efforts to develop cost-effective health care products.

Pharmaceutical companies also continue to attempt to counter the impact of hospital cost-control programs with cost-control efforts of their own. Merck chairman and chief executive officer John J. Horan, for instance, says that, although the dollar's strength and a higher effective tax rate had an adverse effect on the company's earnings, "cost-control measures helped to offset these factors." At Eli Lilly, chairman Richard D. Wood notes that third-quarter results benefited from control of manufacturing costs and operating expenses. He points out that although R&D spending rose substantially in the quarter, other operating expenses were down slightly from the same period last year.

G. D. Searle continued to depend heavily on its aspartame products: Third-quarter sales of \$134 million accounted for 44% of the company's total sales in the period. Searle's continued independence is now a question, however. In September, members of the Searle family, which owns a large number of the company's stock, asked management to consider ways for the family holdings to be diversified. One of the likelier methods of such diversification would be the sale of the firm.

David Webber, New York

Environmental Sampling for Hazardous Wastes



NEW!

Glenn E. Schweitzer and John A. Santolucito, Editors
U.S. Environmental Protection Agency

Underlines the concern and need for improved methods of environmental sampling. Surveys the problems of collecting representative samples, ensuring the chemical integrity of samples from collection to analyses, and characterizing and monitoring contamination sites. Examines the important aspects of designing and implementing sampling programs, emphasizing surface and subsurface sampling for hazardous wastes. Looks into the experiences of federal and state agencies, and academic and institutional organizations. Cites several successful field programs for sampling dioxin, lead, and cyanide.

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Hazardous Waste: Questions and Issues from the Field • Uses of Environmental Testing in Human Health Risk Assessment • Assessing Cyanide Contamination from an Aluminum Smelter • 2,3,7,8-Tetrachlorodibenzo-p-dioxin Sampling Methods • Field Measurement of Polychlorinated Biphenyls in Soil and Sediment Using a Portable Gas Chromatograph • Using Geostatistics in Assessing Lead Contamination near Smelters • Lead Levels in Blood of Children Around Smelter Sites in Dallas • An Approach to Interdisciplinary Design of Multifactor Experiments • Statistical Methods in Environmental Sampling • Soil Sampling Quality Assurance and the Importance of an Exploratory Study • Quality Assurance for Measurement Program • New Ways of Assessing Spatial Distributions of Pollutants • Detecting Elevated Contamination by Comparison with Background

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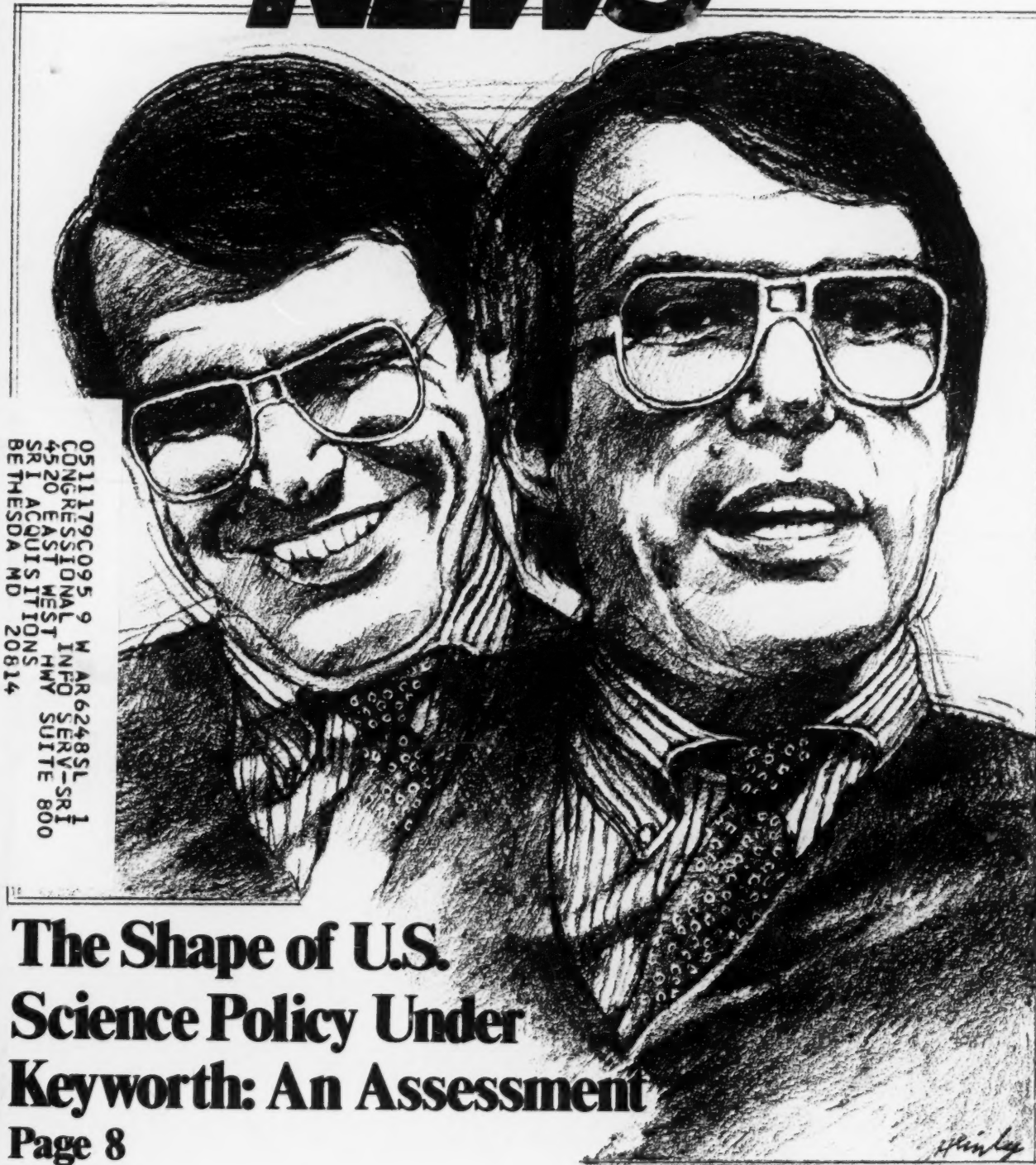
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**The Shape of U.S.
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News Focus

Presidential Science Adviser George Keyworth has scored well with the scientific community, especially by increasing federal support for basic research. **Page 8**

Peers Rate Keyworth Generally High as President's Science Adviser

Keyworth gets high marks on White House access and support for basic science, low marks on intellectual independence; doubts rise over shape of science advice in new Administration

Wil Lepkowski, C&EN Washington

Three and a half years ago, President Reagan surprised the scientific community and appointed as his science adviser a physicist unknown in Washington. His name was George A. (Jay) Keyworth II, son of a New England furniture factory president, a nuclear physicist at Los Alamos National Laboratory, and a protégé of Edward Teller. Teller is, as most know, the physicist who is as famous for his conservative, anti-Soviet politics as for his leading role in the development of the hydrogen bomb.

If Keyworth, 44, was a nobody then, he isn't now. As science adviser he has triggered more controversy and debate over technical priorities than any equally prominent science policy figure in the past. But the reason for this is less his provocative personality than history's ebbs and flows. Conservative by nature, Keyworth came in to serve a conservative Administration, with its blend of aggressive anticommunism and absolutist belief in the moral imperative of the business ethic. So he had a power base and he acted on it, adding an effervescent zeal for scientific discovery.

Keyworth is being given credit for the biggest series of increases for basic research since the middle 1960s, when funding for science was in its heyday. During Reagan's tenure, basic science funding has risen from around \$4.8 billion in fiscal 1981 to \$6.2 billion in the current fiscal year. The scientific community is happy with Keyworth. He has argued success-



Keyworth: forced new thinking

C&EN staff photo

fully for what they want, despite continuing strong differences over arms control issues.

He established a White House Science Council of top scientists and engineers in the country. This group reports not to the President, but to him, unlike the old President's Science Advisory Committee (PSAC) for which the old science establishment still hankers. He told establishment titans early on that they had to begin setting priorities in scientific research, and they did. He helped produce the current climate of close—today almost frenzied—research cooperation between universities and industry. He forced new thinking in the field and gave some excitement to the connections between science and national goals.

Under Keyworth, the National Science Foundation has drastically upgraded engineering research and education through an ambitious goal of funding several engineering research centers at universities around the country. Thanks to efforts of his office, agricultural research is becoming modernized and organizationally revamped toward capitalizing on developments in molecular biology.

Keyworth also pushed successfully for larger funding for competitive research in the Agriculture Department. He reoriented the Department of Energy's national laboratories toward more cooperation with industry and universities. A special OSTP panel issued a report favoring quick regulatory action to prevent further acid rain pollution. And Keyworth has tried to see to it that the Administration develops a coherent policy

on cancer prevention in the environment and workplace.

In short, Keyworth seems to have sought not only to master science policy but to take charge of it. So much so that sources say he harbors visions of becoming the country's first Secretary of Science & Technology.

It is possible, of course, to overplay the influence of a science adviser in any Administration. Science advisers whoever they are may impress and even intimidate their technical peers, but to operatives within the White House inner circle, they are seen more as potential anchors on the political ship. The reason is that the scientist's mental framework dictates honesty rather than expedience.

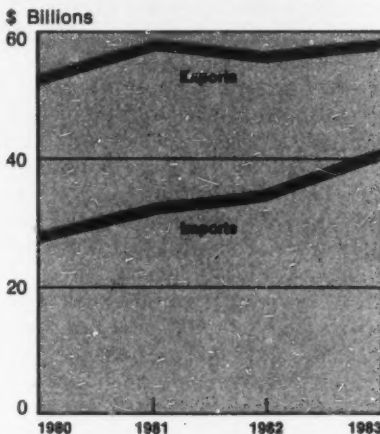
But Keyworth, hawkish, boyishly enthusiastic about science and technology, and bullish on the free enterprise system, could operate honestly within that ideological mindset of the Reagan White House. It was Teller, after all, who urged that Keyworth be appointed after several more senior and savvy science and technology figures refused to be considered. And since Keyworth has on many occasions conferred on Teller an almost spiritual role in his (Keyworth's) development, the appointment made more than good sense.

So what the nation has today is science and technology fashioned in the context of a conservative ideology. It is, in a sense, the Office of Management & Budget's job to fashion and carry out budget decisions congenial to the current ideology. And it is Keyworth's job to explain them. As Presidential envoy to the scientific community, Keyworth has been tireless. He also has been an indefatigable spokesman for excellence in scientific research.

Unfortunately, all this makes him a little suspect with the establishment. For although he has helped give it what it wants in terms of funds and programs, it does not feel he has quite succeeded in balancing party loyalty with complete scientific integrity. Many establishment figures, in fact, are working quietly to help Keyworth grow in his job despite their disagreement with Administration policies.

So people do understand. "I think that considering the general circumstances a science adviser is in," says long-time Washington science watcher Philip Abelson, soon to retire as editor of *Science*, "Keyworth has done a better than average job. There is a jungle in the

High-technology imports growing faster than exports



Note: High technology is defined by such products as communications equipment, electronic components, scientific instruments, industrial chemicals, resins, fibers, and drugs and medicines. Source: Department of Commerce

inner reaches in the White House. Your heart may be the purest and your wisdom the greatest, but if you don't have any instinct in knowing how to thread your way through that jungle you're no damn good."

So judgments aside for the moment, Keyworth has succeeded in articulating a "science policy" for the country. It is that federal science exists to serve industrial competitiveness. Ten years ago, the sentiment was exactly the opposite. Science came under criticism for ignoring quality of life issues and serving the military cause in Vietnam. Those attitudes hold no more. It is a different period of history. And the change has been stunningly swift. For the first time in memory, for example, Massachusetts Institute of Technology reports that research funding from private sources now exceeds grants coming from NSF.

Upbeat is one word that surely characterizes Keyworth. Hear him on policy for science and mathematics education spoken before a group of science writers last month:

Government funding of research and development would surpass \$50 billion in 1985

\$ Millions	Federal funds for R&D by budget function									
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
National defense	\$10,430	\$11,864	\$12,899	\$13,791	\$14,946	\$16,413	\$22,070	\$24,936	\$29,275	\$36,975
Health	2,351	2,629	2,968	3,401	3,694	3,871	3,869	4,298	4,801	4,913
Space research & technology	3,130	2,924	2,982	3,009	2,981	2,896	2,584	2,134	2,286	2,683
Energy	1,849	2,582	3,134	3,481	3,603	3,501	3,012	2,578	2,565	2,422
General science	858	874	1,050	1,119	1,223	1,340	1,359	1,502	1,717	1,942
Transportation	631	708	768	798	888	876	791	878	1,091	1,148
Natural resources & environment	683	753	904	1,010	999	1,061	965	952	985	900
Agriculture	383	457	501	552	583	659	693	745	760	795
TOTAL	\$20,780	\$23,542	\$25,994	\$28,080	\$30,017	\$33,319	\$35,968	\$38,768	\$44,367	\$52,860

Source: National Science Foundation

"Incredibly good things are happening today. It's incredibly anachronistic for national leaders to be talking about the federal government leading a charge for science and math education when we are seeing a better job occurring in states and regions than anything the federal government has ever been able to accomplish. The North Carolina School of Science & Mathematics is a model no federal government could ever devise. If the federal government supported that it would be crass elitism. More and more bond issues are being passed to support standards and teacher salaries. Teachers clearly are drastically underpaid. They have to be elevated [in stature] to reflect their value.

"The government is trying to respond to this mood by high-leverage activities. We brought the best teachers to Washington. They got awards, saw the President. It was enormous leverage, though it cost next to nothing. Some of us are very excited about the fact that new technologies offer the possibility to pay careful attention to the learning process. We can ask ourselves how we can use this technology to make use of the student's learning process far more efficiently. I think the field of cognitive science is truly beginning to display vestiges of true science. And that field along with technology will help us develop a science of learning as contrasted with the science of teaching."

Keyworth is refreshingly candid about his assessments of what he feels needs changing in government science and technology. Take, for example, these comments he made to the same meeting on two agencies currently undergoing scrutiny:

"We haven't as yet been able to wrestle effectively with the National Oceanographic & Atmospheric Administration. There's a lot of poor quality work there. I worry about the National Institutes of Health as much as anything. There they are making the transition between an era when biology was supported for its impact on biomedical research and health care, to a time when biology represents broad new disciplines that impact upon everything from mining of materials to industrial chemicals.

"We are not making that transition well. We have not for 10 years paid adequate attention in our biomedical research priorities and allocations to the kind of people we're drawing into these fields. ... The willingness and ability of NIH to address the kind of talent that comes out of its research program has not been up to the needs."

In short, Keyworth is identified with designing a science and technology policy more geared to the capitalist market system than any science adviser in the 40-year history of the ilk. And he apparently isn't satisfied to stop there. For if Keyworth's prayers are answered, President Reagan will announce next year plans for establishing a Department of Science & Technology. The President's Commission on Industrial Competitiveness, comprised of several executives from high-technology companies, made the recommendation for such a department at its meeting in Dallas in late October (C&EN, Nov. 19, page 6).

But the White House staff may have other plans. The President may announce, instead, a drastic cut-back in the executive branch. Sources who can't be named are beginning to say that the White House inner circle is contemplating elimination of Keyworth's position and OSTP. Some have been suggesting that Keyworth is hoping the commission possesses enough influence with the President to endorse his function and, in fact, elevate it. In any case, the science adviser has become less shy about promoting the idea. And, in the end, if the White House decides the President needs merely a special assistant to the President for science and technology, Keyworth could be well positioned.

Meanwhile, Keyworth leads the cheers for federal support for good science, often to a fault. "Keyworth is faster to the tin cup than any science adviser before him," says one long-time participant in the wars over science and technology budgets. "The worst example of that was OSTP's attempt to establish the Berkeley materials lab without much input from the materials science community." This source was referring to Keyworth's attempts to establish at the Lawrence Berkeley Laboratory an Advanced Materials Research Center. Materials scientists around the country protested that they were not consulted and the lab, though now established, lacks the expensive synchrotron light source that was to be its centerpiece.

Even Republican colleagues fault him on that one. Edward E. David Jr., a member of Keyworth's science council, science adviser under President Nixon, and currently president of Exxon Research & Engineering Co., says, "I think one of the mistakes Jay made was his support of the Berkeley center. That's one of the few things that led to all the pork barreling of university research facilities we're seeing today."

One technology policy figure who clearly has high grades for Keyworth is Robert M. White, president of the National Academy of Engineering and for many years director of the National Oceanographic & Atmospheric Administration. The engineering academy performed the study on engineering education that led to establishment of NSF's engineering research centers program. The first engineering research centers grants are due to be announced in March.

"I think Jay Keyworth has been enormously successful as science adviser on whatever measures one might use," says White. "Funding for basic science has grown faster than at any time during the past 13 years. He has fashioned a conscious policy to make sure of that funding support in areas on which the future of the country depends. I think also that he has recognized the need for major changes in engineering education, training, and support. Out of that has come NSF's engineering research centers program. You have to give the guy credit. He has reached out to the community [to determine priorities for science and technology] and has been very upbeat."

Another big booster is Roland W. Schmitt, senior vice president for corporate technology at General Electric and chairman of the National Science Board. Says Schmitt: "I think Jay has been an extraordinarily

Keyworth's views on selected subjects

On the National Science Foundation's Engineering Research Centers:

"The centers are means by which multiple disciplines can get together outside of the departmental context of presumed problems. But most of all, the program is a cultural bridge. And it's a mechanism that we'll see expanding beyond engineering and very much encompassing the sciences, too. Suppose industry wants to draw upon academic talent to address defects in semiconductor gallium arsenide. Where do they go? To a physics department to get the materials science experts? To a chemistry department? To an engineering department? The problem is that universities are not structured to solve problems. They're structured along disciplines so they ensure that someone who gets a degree in any area of science has met certain standards. We also need problem-solving mechanisms on campus so that students will become familiar with the types of problems they'll be solving when they get outside. That way we can narrow the cultural gap between the ivory tower and competitive industry."

On establishing a Cabinet-level Department of Science & Technology:

"It's time we gave very hard thought to how we handle one of the most precious resources we have, our science and technology base. Maintaining the cutting edge in science and technology is absolutely essential to our future. It has got to be an elevated priority. It deserves to be closer to the policy-forming apparatus that the President maintains, and we need a more direct mandate to couple policy and

implementation. There's considerable interest in it among White House staff. Many find it an interesting issue worthy of some deliberation."

On charges that Rep. Don Fuqua (D-Fla.) sidestepped the peer review process in securing for Florida State University a supercomputer funded by the Department of Energy:

"I think Don Fuqua's been erroneously maligned. There has been blatant pork. And that came in through universities that went to lobbying organizations in Washington and tried to literally play the process. That is sheer unadulterated pork. Don talked to me from the very beginning about that supercomputer opportunity in Florida. He was interested in it; it was spontaneous in Florida, and from the very beginning his argument to me was, 'Jay, I want nothing but quality in my state and I'd appreciate your technical judgment as to the quality of that project.' He was using me for my honest opinion of whether this was a first-class facility. First of all, I said I would give him my opinion. Second, I gave him my opinion. I said they have a very good and very promising computer science capability. What they have in mind is very much what we are trying to do in stimulating supercomputers, and I will continue to give my objective views on it. I did all the way along. There was no pork. It bore no resemblance to what was being done via the lobbying process. There was careful comparison to other opportunities in other agencies."

On whether the time is ripe for another space spectacular:

"I think the American public needs to better understand what the opportuni-

ties are in manned space flight, whether they be Mars, asteroids, the manned lunar station, whatever. And I think the public needs to decide whether it is an important priority to them. I don't think we should look back to the Apollo project, but I think we should recognize that the public owns the civil space program. It is more public property than almost any federal program that I'm intimate with. And I think the public should make that decision. I look forward to the commission on space that we're working with now."

On the Star Wars controversy:

"Star Wars has been very much caught up in the political campaign. It became a highly political issue at the outset. You will find a remarkable alignment between political inclination and opposition or endorsement of Star Wars and I think it's much too serious an issue for that. One of the things I found most disturbing was the fact that there are hundreds of thousands of scientists in the U.S. but only about 20 people who have criticized every strategic step taken by this and the previous Administration. There have been constant accusations that if the President's Science Advisory Committee had been around it would have reviewed it. Well, we have a group called the White House Science Council. It was intimately involved. The only difference is that the White House Science Council has achieved its credibility by being quiet. I admit that we as an Administration certainly could have done a better job of working together amongst us all to develop a clear-cut strategy and policy associated with it."

effective science adviser. I remember when he went into the office and made it clear that he would act as a member of the President's staff and on behalf of the President, rather than as a representative of the technical community in the White House. That didn't go over well with the community. Yet everyone would have to agree now that he was extremely effective."

Further praise comes from Ivan L. Bennett Jr., dean of New York University school of medicine and a deputy director of the White House Office of Science & Technology in the late 1960s. "I think that Keyworth has done a very good job," says Bennett. "He was a relative unknown when he was appointed and has

grown into the job, and has become very effective. He's been effective in the sense that he has to the best of his ability given the President advice on matters of national policy in science and technology. He has demonstrated that there is someone in the White House who is listening to him. His advice has come from judicious tasking of policy issues, like the Academy of Sciences' priority reports. He has built on the foundations of Frank Press. He has been very skillful at treading the fine line between being the representative of the scientific community and being the President's science adviser."

Keyworth is very much the team player more than



White (left), Golden (center), and Schmitt praise Keyworth, feel that he has been a very effective science adviser

he is the generator of new ideas and informed criticism within the White House staff. So in that sense, though bright, he could be in danger of being intellectually the most compromising science adviser by virtue of the Administration he serves.

He had no apparent role in the debate over yellow rain, had little public to say about scientific secrecy in the face of national security needs (indeed, sources say, he has little role at all in the inner circle of national security matters, where outside technological advice is most needed), and cannot be regarded as the type of thinker who ponders science in the context of the broader needs of humanity and nature.

Consider this quote from a speech by Keyworth to the Woodrow Wilson Center in Washington two months ago: "Only a few years ago," Keyworth said, the U.S. was in "near panic" over the technological threat from Japan and Western Europe, who were "10 feet tall and growing." But "our perceptions have changed," he said. "We've recuperated from our brief lapse of common sense. Our recovery over the past few years—and by that I mean both economic and emotional recovery—has transformed our attitudes toward these foreign challenges. When we look around the country today, we see very few industries still trying to hide from competition, and most of them are ready to take on all comers."

But on specifics, Keyworth wasn't so keen as his rhetoric. Which industries were trying to hide from competition? Steel? And isn't it still? Auto? Isn't it doing better than ever, yet still insisting on Japanese import quotas? Machine tools? Is it really any better off in its balance of trade figures?

Keyworth, who is on record as minimizing the importance of the social sciences, says the country has recovered "emotionally." But on what scale of measurement? Who has recovered? And of those who were emotionally destitute, were they the urban and

rural blacks? Farmers? Indeed, bankers? And if so, are they feeling any better?

"What bothers me most about Keyworth," says a Congressional staff person who has dealt with science policy issues over the years, "is his poor communication with Congress and the public. The White House science group is a closed society. It doesn't care to communicate with the rest of the world. In his hopes that the President will establish a Department of Science, you would have thought he would have come up to the Hill and talked to all the key committee chairmen to pave the way for the politics that will be involved."

Any talking to Congress about a science department at this time probably would be premature. And all Keyworth is saying, anyway, is that the topic deserves serious discussion. Moreover, he does have that handicap as a scientist: A science adviser cannot be expected to serve above the politics of the Administration in power. Lee Dubridge, observes John M. Logsdon, director of the program on science and technology policy at George Washington University, was the last science adviser who came in defining his role as the representative of establishment science to the White House. But in short order he was disabused of the attitude by the Nixon White House. So after little more than a year, he resigned.

"I think the problem with Keyworth," comments Harvey Brooks, professor of technology and public policy at Harvard University, "is that his advice has had too little independence from the ideology of the Administration. Frank Press straddled the line successfully between fulfilling the staff function to the President and reflecting the kind of independent advisory role a science adviser would symbolize. Keyworth is too subservient to Presidential politics. The best example is the Strategic Defense Initiative (Star Wars). This is an area where the science advisory office could

have been acting as a confidential and responsible critic. But as far as I can make out, Keyworth was a proponent of it without understanding all the issues very well.

"In the old days, a PSAC would have jumped in and kept the President from going out on a limb. In another area, Keyworth, by promoting the Berkeley advanced materials lab, seemed to invite Congressional initiatives into establishing other centers."

Today's science office, adds Brooks, "does not reflect the social changes running through society." But he says a science adviser would run into a political "dead end" by promoting understanding in today's White House. "The whole atmosphere," says Brooks, "is that of an Administration out of tune. Keyworth came in without any broad understanding of the broader issues."

John P. Holdren, a physicist at the University of California, Berkeley, and a member of the largely invisible Scientists & Engineers for Mondale during the election campaign, gives credit to Keyworth for his "forthrightness" in explaining his role as the President's science adviser. "I admire him for his willingness to tackle top issues head on as he has repeatedly done," says Holdren. "I admire him for the vigor with which he has argued the case for basic research within the Reagan Administration. I imagine that in many respects he's had an uphill fight. He has fought for science capably and in many respects successfully."

But there the compliments cease. "Unfortunate trends," such as the increase in the defense budget, decrease in the size of nondefense research and development, and curtailment of scientific exchanges with East bloc countries are bad enough, says Holdren. But the Administration also shows "profound misunderstanding of the nature of the energy problem and ways in which market incentives fail to address important aspects of the problem or actually make them worse."

"More remarkable," says Holdren, "is that Reagan has not even applied consistently this market-oriented view. The Administration has repeatedly requested more for fission R&D than Congress has been willing to appropriate. And the sum for nuclear fission R&D still exceeds the sum of the request for fossil fuels, renewable sources, and conservation R&D put together. With the enormous sums of money the government has poured into nuclear fission over the years, it seems that this energy source should be making it in the marketplace without further large infusions of research and development money."

"One element of the failure of this Administration is its failure to take into account the energy needs of the rest of the world. We in the industrial countries are the only people who can afford major investments in energy R&D. And yet historically we have made those investments as if the world's only energy needs were those that could be met by technologies appropriate to our own economic and cultural contexts."

Over past weeks, indications are that Keyworth is opening himself up to outside advice from some of

the science policy old guard. These are ideologically neutral individuals who won't speak for publication but feel strongly that the White House science function is more crucial than ever in meeting a whole convergence of domestic and international problems.

What they bemoan most is the decline of independent science advice in the national security and arms control areas. To their observation, Keyworth and his Science Council have less than minimal input into the National Security Council and the Pentagon. "A science office is good for balancing the Pentagon," says one. "And it should co-relate to the National Security Council. This Administration has not followed that, and, of course, President Carter destroyed the whole idea. Keyworth's council was supposed to function like PSAC, but it doesn't. It is not doing any national security work, and in the process, Keyworth has been out of step with the national science community over Star Wars."

The charge is a serious one. And it is easy to see how Keyworth could be in a bind as he melds with the scientific establishment he hardly knew in his first few months. He reports that he lately has been reading the book, "Science Advice to the President," edited in 1980 by William T. Golden, a New York investment banker who in the 1940s first suggested the idea that the President should have a science adviser.

"My impression," says Golden, "is that Keyworth is getting better and better all the time, especially when you consider that he started with the shortcoming of having no experience in Washington. People tell me that his Science Council is not encouraged to generate many new ideas. They're more a sounding board for him. As a result a narrow 'gene pool' of ideas is available to the President."

Adds Golden: "I think PSAC would introduce new ideas to the President himself, in coordination with the science adviser. Members would have a feeling of being useful in a way that being an adviser without Presidential appointment would not have. They would get encouragement to think of novel ideas and they would want him to hear them. But I really have no reason to think Reagan wants the introduction of outside ideas. Perhaps in his second term, Reagan will be more interested to hear them, however."

What is obvious is that science advice is much more complicated than it was in its early days of sputnik and antiballistic missile development. Then, its politics was minimal, and Presidents Eisenhower and Kennedy genuinely knew they needed a counterbalance in advice to weigh against schemes of a technologically ambitious but unsophisticated military.

Today, science and technology riddle politics and policy. Their logic, in fact, tests it. So the political advisers around any President may want to protect him or her from too much logical advice. In other words, science policy may have become so mature that it must be kept at bay in an era of subtle and not so subtle media-delivered propaganda. Few should be surprised, then, if Reagan's staff decides that eliminating OSTP serves the interests of his second term. □

Industrial Gases Settling into Slower Growth Pattern

Slowing rate of consumption of oxygen, nitrogen, and supply-plagued carbon dioxide plus capacity shakeout points to maturing industry

Bruce F. Greek, C&EN Houston

The industrial gases industry shows many signs of maturing. It has recovered very well from the recession. Its growth, excluding swings from recessions, is settling down to 1.5 to 2.0 times that of the gross national product—except for carbon dioxide because of its difficult supply situation. And the industry's excess capacity has been reduced through the shutdown of obsolete plants and little new construction in the past two years.

Production at air separation plants in 1984 will be up 10 to 15%. This increase includes both nitrogen and oxygen. New highs in output of nitrogen will be set this year and likely will continue to be set in fu-

ture years. Production of oxygen, however, though up significantly, could be a long time in matching its previous high set in 1979.

As might be expected in the maturing of products, contrasts also are developing. Differences between nitrogen and oxygen in their outlooks are examples. Fast-growing uses have been developed for nitrogen, helping to spur plant building and technology development. But oxygen has had prospects of high

industry declines and rises with the economy.

In contrast, oxygen faces much slower growth if the restructuring of the steel and chemical industries continues. If imports of steel and chemicals replace domestic production, then oxygen demand could falter in the U.S. Even the use of oxygen in partial oxidation processes could slow as a result of the slowing in demand for heating oils and a leveling of demand for gasoline.

Carbon dioxide also is confronted with little growth in production. But this is not because of a lack of demand. Supply problems have plagued carbon dioxide producers for quite some time, and they seem to be getting worse. Because carbon dioxide is a coproduct, it depends on production of the wanted product. In the case of ammonia production, the largest source of carbon dioxide, a shift has been under way to foreign sources, which have access to much lower-cost natural gas.

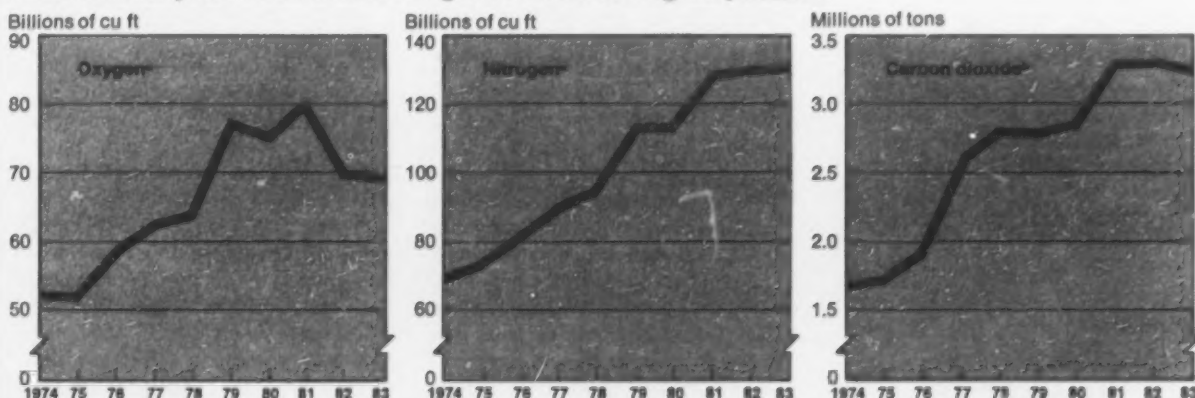
For a more detailed look at these industrial gases, see the following pages.

Key Chemicals

growth demands dashed by big cut-backs in projects to gasify coal.

The enhanced oil recovery (EOR) uses of nitrogen likely will keep demand for this gas moving ahead for many years with only the possibility of a large decline in world oil prices as a potential damper on growth. Use in this area likely will pull along total nitrogen consumption even as demand in the metals

Merchant shipments of industrial gases show divergent patterns



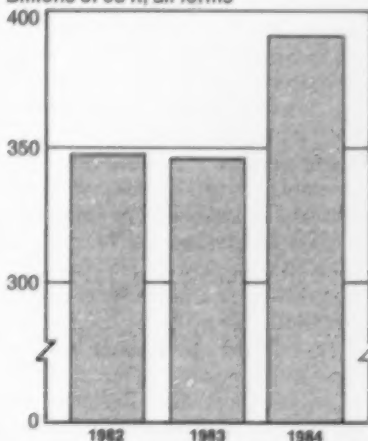
a Cylinder and bulk delivery. b Data for 1974 through 1980 believed understated; reporting for 1981 through 1983 not comparable with earlier data.
Source: Bureau of the Census

Oxygen

- Demand higher
- Capacity holding
- Prices up slightly

PRODUCTION

Billions of cu ft, all forms



TOP FIVE PRODUCERS

Air Products, Airco (BOC Group), Big Three Industries, Union Carbide, Liquid Air

HOW MADE

Separated from air at low temperatures; pressure-swing adsorption using various molecular sieves

MAJOR END USES

Primary metals manufacture 30%, metals fabrication 30%, chemical manufacture 20%, partial oxidation processes 10%

FOREIGN TRADE

Negligible

PRICES

Merchant sale list prices 53 cents per 100 cu ft plus delivery and equipment charges

Oxygen production during 1984 will keep pace with the general economic recovery, probably increasing about 12 to 14%. This gain will follow a flat year in 1983, after a decline of nearly 20% in 1982. Production of oxygen in 1984 likely will reach 390 billion cu ft, still well below the 430 billion cu ft produced in 1981.

Thus, though oxygen production has improved, it is yet to return to its former highs. These highs could be a long time coming. The major uses of oxygen, which are in the metals industries and which take some 60% or so of consumption, could lag for many years, holding down total demand. Hopes for topping former output levels, therefore, depend on development of other current uses and new uses.

Capacity to produce oxygen either by air separation or by pressure-swing adsorption continues to be in substantial oversupply, especially for captive and for pipeline delivery sales. Most of this oxygen production goes to steelmaking and chemical manufacture. New capacity being built is small because of this oversupply, with most new capacity going to replace obsolete units or to meet demand in a new location. Until some of the new uses expected for oxygen get moving, capacity expansions will be minor.

Steelmaking accounts for nearly one third of oxygen production. Consumption of oxygen for all of 1984 depends heavily on how well steel does during this quarter of the year. Earlier in 1984, demand for steel rose strongly. Prospects then were good for the entire year. A long auto strike seemed to be unlikely during the second quarter, causing steel production to exceed demand even with most auto plants running nearly all out. Inventories of sheet steel used in autos and in appliances rose to levels considered excessive, partly aided by imports of steel. During the third quarter, spurred by the short strike of auto workers at General Motors, inventory cutting began and continues even now.

At the same time, some steelmakers expected capital goods demand for steel—large beams and plate, for example—to increase during the second half of the year. Inventories of these forms of steel also rose. Now that it has become clear that this area of steel demand will not be very large in 1984, inventory cutting is under way where possible.

The other major area of metals' use of oxygen is in fabrication, both cutting and welding of steel. This use has declined during recent years and seems unlikely to grow very much until another strong capital goods boom occurs.

Chemicals manufacture accounts for nearly 20% of oxygen consumption. Ethylene oxide production accounts for about half of this consumption. Other chemicals using oxygen in their production include acrylic acid, propylene oxide, and vinyl acetate.

Partial oxidation processes could be included with chemical manufacture but are more specialized, with two processes accounting for most of the consumption. One is the partial oxidation of the residual fraction of petroleum to make synthesis gas or hydrogen alone. The other process involves use of oxygen in fire flooding of oil reservoirs to enhance oil recovery. This use works best with heavy crudes and offers an alternative to use of carbon dioxide in enhanced oil recovery, but it remains dependent on special oil production situations.

These new uses indicate that a degree of change is under way in oxygen consumption, which might help producers over the long term. Steel and its fabrication could be declining slowly as a use because of imports of both steel and products of steel such as autos. Chemicals' use of oxygen also may later be hurt by imports. New uses, such as partial oxidation processes or air enrichment, soon may grow fast enough to offset any declines in older uses and keep demand for oxygen rising.

Key Chemicals

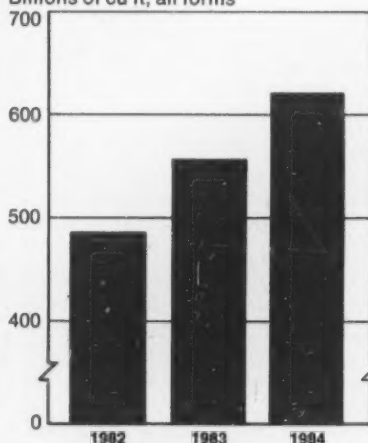
N₂

Nitrogen

- **Demand stronger**
- **Capacity holding**
- **Prices improved**

PRODUCTION

Billions of cu ft, all forms



TOP FIVE PRODUCERS

Air Products, Airco (BOC Group), Big Three Industries, Union Carbide, Liquid Air

HOW MADE

Separated from air at low temperatures; pressure-swing adsorption using various molecular sieves

MAJOR END USES

Blanketing atmospheres for chemical processing 25%, enhanced oil recovery 20%, electronics manufacturing 15%

FOREIGN TRADE

Negligible

PRICES

Merchant sale list prices 49 cents per 100 cu ft plus delivery and equipment charges

Production of nitrogen is still moving ahead smartly. In 1984, output for various uses, except for making ammonia, could exceed 620 billion cu ft, up about 12% over 1983 production. This follows a gain of about 15% in 1983. Such steady increases in production contrast with production gains for oxygen, which, although good in 1984, were on hold in 1983.

All of nitrogen's large end uses are continuing to grow, although some have significantly better growth rates than others. Some, such as enhanced oil recovery (EOR), will grow at twice the average rate of 12% during 1984. Others, such as metals uses, will be half the average growth rate. The gain in EOR consumption of nitrogen, a relatively specialized area, has been so large that its share of total nitrogen consumption has increased and has taken a percentage point or so out of each of the other major uses.

EOR will account for about 20% of total nitrogen production or about 120 billion cu ft of nitrogen in 1984. Most of this consumption will come from air separation plants dedicated to making nitrogen for EOR. Such plants are designed to maximize nitrogen production with the oxygen returning to the off-gases stream. Usually, these air separation plants are so far from an oxygen use site that it is uneconomical to ship the oxygen. Such plants contrast with those installed at or near steel mills that have oxygen as their primary product for use in basic oxygen furnaces.

Several different uses of nitrogen are involved in EOR projects, helping to spur demand. The particular application at a given location depends heavily on the geology of the reservoir and on economics of potential oil production. The largest use by far is pressure maintenance to drive crude oil through the reservoir to producing wells. Sometimes nitrogen is used as the driving force to move the alternate slugs of water and of carbon dioxide that are put into a reservoir. Nitrogen use in

EOR will be up 20 to 25% over last year, partly because new air separation plants have been coming on stream to supply this nitrogen.

Chemical processing is feeling the challenge from EOR as the largest use of nitrogen. Most chemical processing uses are as blanketing atmospheres, particularly in vessels where polymerizations and other specific reactions are run. Other uses in chemical processing run the gamut from fire prevention to drying and purging. Conveying polymer pellets has become an increasingly important use, although as yet it is relatively small volume. The various chemical plant uses could amount to 150 billion cu ft this year, or about 25% of total consumption.

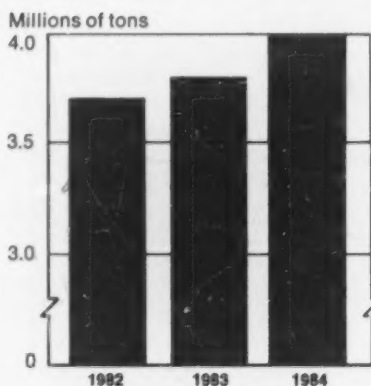
Electronics manufacturing has been another major market for nitrogen. Growth in this area has slowed appreciably, however, from more than 20% annually to about 10%. Still, the rise has continued to give high profit margins to suppliers of nitrogen, because of the increasingly stringent purity requirements of many electronics manufacturers. Manufacturers have been willing to pay premium prices for nitrogen with impurities in the parts-per-million range. The volume of use of this kind of nitrogen, of course, is small when compared to the volume used in most applications.

Among other uses, those in the metals processing industries, largely steel, may account for about 15% of total consumption. Because of their heavy dependence on the general economy, these uses as a group swing up and down significantly. Their growth probably will average about 5% annually over the long term. Food freezing, especially the more valuable items such as meats, poultry, and seafood, has slowed as a consumer of nitrogen, largely because the demand for fast food has slowed. Aerospace, cryogenic grinding, glass making, medical, and others as a group all will grow slowly as nitrogen uses. However, they probably won't help overall growth much.

Carbon dioxide

- **Supply limited**
- **Capacity inadequate**
- **Prices varying widely**

PRODUCTION^{a,b}



^a Recovered for merchant sale and captive uses excluding urea manufacture; does not include carbon dioxide recovered for use in enhanced oil recovery.
^b C&EN estimates.

TOP FIVE PRODUCERS

Airco Industrial Gases, Air Products, Chemetron, Liquid Carbonic, UGI

HOW MADE

Recovered from gas streams produced for ammonia manufacture, hydrogen processing, fermentation processes (ethanol), chemicals manufacture, and natural sources

MAJOR USES (nonoilfield)

Refrigeration 30%, beverage manufacture 25%, chemical manufacture 10%, welding 10%

FOREIGN TRADE

Exports—negligible, imports—small, 1 to 2% of consumption

PRICES

List prices vary widely, but average about \$75 per ton

Carbon dioxide could be unique among major volume industrial chemicals. It has the unusual advantage that more of this gas could be sold to its merchant markets if it were available. This supply limitation, however, applies to just a small part of the demand for carbon dioxide—the merchant market amounts to about 5% of total consumption. The remainder of carbon dioxide production and consumption involves captive or near-captive use in petroleum and natural gas operations.

The unusual supply situation for merchant carbon dioxide stems from the fact that it is a frequently unwanted coproduct in the manufacture of some other material. Most of the carbon dioxide going to merchant and commercial markets is captured from the production of ammonia and hydrogen by reforming natural gas, from making ethanol and other products by fermentation, and from making other chemicals. Most of the carbon dioxide used in enhanced oil recovery (EOR) comes from producing natural gas containing high concentrations of carbon dioxide.

These two areas of carbon dioxide production and consumption are so separate that they seldom are considered together. Production data for the smaller merchant supply of carbon dioxide are reported to the Bureau of the Census, and estimates of use patterns are made by various producers.

No data, however, are reported on the captive production from gas wells and consumption in EOR. Here carbon dioxide frequently is produced from gas wells owned by an oil and gas company and is consumed entirely in the company's EOR operations. In other cases, the carbon dioxide is sold under long-term contract by the producer to a single, nearby consumer. The carbon dioxide involved in EOR operations generally is not considered to be an industrial gas because data are not available, it comes from a single source, and it has a single use.

In the merchant category, production data seem to be underreported,

according to some industry sources. This is due partly to the fragmented sources and partly to the kind of operations—some are seasonal—that yield coproduct carbon dioxide.

Production of carbon dioxide from ammonia plants, its largest source, is estimated to increase 5% this year to about 4 million tons, raising the availability of carbon dioxide. Production of hydrogen, another carbon dioxide source, for use in refinery hydrogenation processes also rose some this year, increasing the availability of carbon dioxide, but to a much smaller degree. However, a substantial part of this carbon dioxide supply may move to captive uses in EOR operations of the refinery's parent company.

Recently, a new source of carbon dioxide—grain fermentation to make ethanol for fuel uses—began to develop rapidly. But again, unfortunately for carbon dioxide supply, the growth of ethanol use for automotive fuel depends also on economics and politics such as tax incentives for plant construction, world demand and prices for grain, and crude oil and refined product prices.

With supply as the major problem for carbon dioxide producers, the incentive to develop uses remains limited. The major uses of carbon dioxide, such as refrigeration and making beverages, are projected to grow at about the same rate as that of the gross national product.

One new use with good potential for growth has resulted from the approval earlier this year by the Environmental Protection Agency of carbon dioxide as a fumigant for stored grain. Safety and the lack of any residue could make this use soar.

The merchant carbon dioxide business, tiny when compared to EOR, may not be growing very much because of limited supplies. But with a few uses for which no substitutes exist, the business may be a good one for those producers willing to struggle to meet the demand.

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Cover: Computer graphics-generated view of B form of DNA produced by Computer Graphics Laboratory, University of California, San Francisco. Red dots describe oxygen atoms, blue nitrogen, green carbon, yellow phosphorus, and white hydrogen. Copyright University of California

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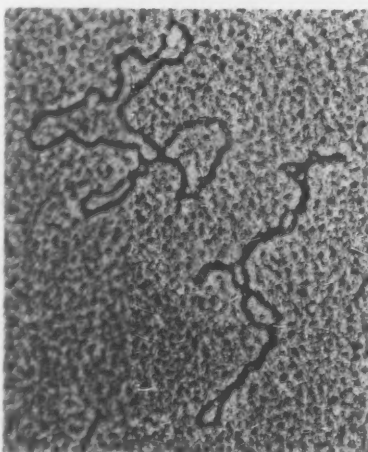
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Biotechnology Firms Gird For Clash over Patent Claims

As more biotechnology patents are issued, disputes multiply, leading more companies to beef up their patent departments

David Webber, C&EN New York

One necessary task this past year for the fledgling companies that make up the small-firm portion of the biotechnology-related industry has been to mesh their scientific prowess with equivalent business capability. In the ongoing transition from an array of research and development boutiques to commercial entities with products, the small entrepreneurial companies have vigorously recruited marketing and production experience from the pharmaceutical and chemical industries. Top managers from Dow Chemical, Du Pont, and several drug houses have made the jump to the small side.

Most of the new employees have been brought on to help answer the broad questions of which products to commercialize, which to license, and which, in some cases, to abandon. At the same time, however, the firms have not lost sight of the proposition that, as with any new technology, biotechnology opportunities will depend to a great extent on protection of intellectual property. In a year that saw the foundations laid for the first major biotechnology patent dispute—between Biogen and Hoffmann-La Roche over Biogen's European patent on α -interferon—companies have moved to beef up their patent departments as well.

Earlier this year, for example, Genentech, the most prominent



Kline: litigation will play key role

smaller company in the field, hired a 32-year veteran of Eli Lilly and a nine-year veteran of Travençolo Laboratories as chief patent counsel and senior patent counsel, respectively. "The addition of these key experts is a strong indication of the importance Genentech places on patents," says president and chief executive officer Robert A. Swanson. "As we approach the marketplace, we expect our products to be well protected by patents. We also will have the capability to enforce those patents, where required to prevent others from capitalizing on our investment in pioneering research."

This kind of tough talk is becoming more common as companies begin to clash over patent claims. Because in many cases several companies are using the various techniques of biotechnology to seek the same or similar products, it is widely expected that the industry will be a very litigious one in the years to come.

"Litigation is going to play a very important role in this area over the next few years," says Robert C. Kline, chief counsel of Du Pont's patent division. That's "primarily because there are some areas of uncertainty, but in addition to that, you've got an awful lot of [people] out there who are investing an awful lot of money in this thing for the future. And the upshot of that is that when you've got a number of people who are going to be plowing in the same field, so to speak, it is going to lead to litigation."

What those in the biotechnology field are trying to gauge now is to what extent litigation is inevitable in their particular area and to what extent it is avoidable—and at what price. Patent litigation is considered one of the costliest types of legal dispute. For the smaller companies in the field, especially, there are undoubtedly some difficult choices ahead in terms of which inventions they can afford to defend.

Consequently, those companies and their large counterparts as well would like to see certain aspects of the patent situation clarified. Although biotechnology's gray areas in the patent arena are similar in the main to those of other advanced technologies, there are questions relating to such aspects as the breadth of patent claims, the ability to differentiate one invention from another, and the patentability itself of some potential products that many experts consider unique to the field.

Disputes seem certain to increase as more and more patent applications are filed. The volume of biotechnology-related patent applications has increased sharply each year for the past several years. According to the U.S. International Trade Commission's study on inter-

SPECIAL REPORT

This year is slated to go into the books as a period of solid growth for the chemical industry throughout the world.

Increased demand from a host of chemical-consuming industries has led producers in the U.S. and other parts of North America, in Western Europe, in Japan, and elsewhere to boost their output and has sparked a healthy improvement in earnings.

The rebound, however, has not dispelled several long-standing problems. Competition in world markets remains stiff—and is expected to become more intense during the next year or two as new producers of petrochemicals strive to carve out a share of world trade. The unprecedented strength of the U.S. dollar, meanwhile, has severely disadvantaged U.S. chemical companies, both at home and abroad.

Now, moreover, concern is rising that growth in chemical consumption is slackening. If it indeed is, the persistent threat of excess capacity and inadequate return on investment may continue to bedevil the industry. Chemical companies recently have taken giant steps to improve efficiency, rein in operating costs, and seek out new, more lucrative markets. A period of slower, if any, growth is likely to retest their mettle and to demonstrate just how meaningful the changes of the past few years actually are.

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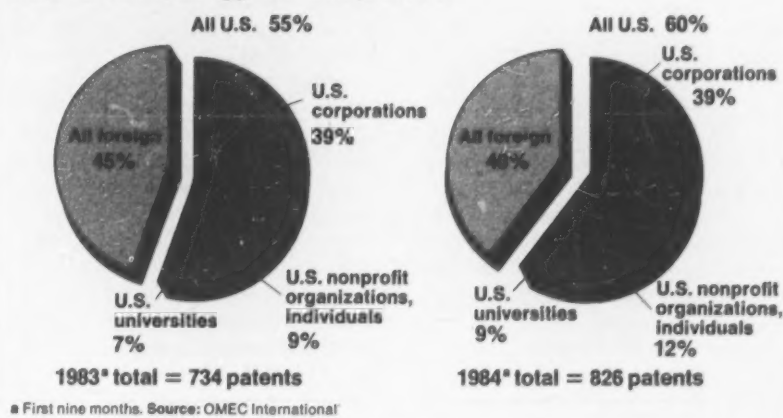
national developments in biotechnology, released in October, the number of such patents issued by the U.S. Patent & Trademark Office grew from 92 in 1979 to 234 in 1980, 313 in 1981, and 372 in 1982. (These figures, based on official Commerce Department statistics, are cited from a patent office study of six areas of biotechnological products and processes.)

The proliferation of biotechnology-related patents is hardly surprising, considering the speed with which advances are being made. Less expected, perhaps, is the pattern of patent activity. Of 826 biotechnology-related patents assigned by the Patent & Trademark Office during the first nine months of 1984, a total of 326, or some 40% of them, were assigned to foreign parties, according to a survey of data compiled by OMEC International, a Washington, D.C.-based consulting firm. Of the 500 granted to U.S. parties, OMEC's survey points out, 321 were assigned to domestic corporations, 78 to universities (or related bodies), and 101 to individuals and nonprofit organizations such as Research Corp.

The pattern is not a one-time phenomenon. Surveying data for the first nine months of 1983 (for comparative purposes), OMEC finds that, of a grand total of 734 biotechnology-related patents, 45% were assigned to foreign parties, and the 55% gained by U.S. concerns were distributed about as they were this year among corporations, academia, nonprofit bodies, and individuals. Similarly, the patent office study cited in the ITC report put the foreign to domestic ratio of such patents at 51:49 in 1979, 49:51 in 1980, 45:55 in 1981, and 43:57 in 1982.

Although the share of each year's biotechnology-related patents assigned to foreign parties has been shrinking steadily, it is still large—a sign of overseas inventors' assiduousness in staking out places for themselves in the U.S. market. In terms of individual countries of origin for U.S. patents in the field, the most active by far has been Japan. According to OMEC, for instance, Japanese inventors accounted for 46% of such patents assigned to

Foreign concerns gain large share of U.S. biotechnology-related patents



foreign parties in the first nine months of 1984, up from 42% in the equivalent 1983 period. The other major foreign countries of origin have been West Germany, Britain, and France.

Oskar R. Zaborsky, president of OMEC and a former program director at the National Science Foundation, notes two other aspects of biotechnology-related patent activity so far. First, he points out, despite the greater amount of attention paid to the smaller biotech-

nology-based firms, most of the patents in the field assigned to date are owned by large corporations. Over the first nine months of 1984, for example, companies such as Du Pont, Hoffmann-La Roche, Eli Lilly, Merck, Miles Laboratories, and Upjohn were assigned 10 or more biotechnology patents. By comparison, well-known small companies gained far fewer patents. For example, Genentech won five patents, Cetus three, Genex one, Molecular Genetics one, and Biogen, Collaborative

Large corporations get most biotechnology-related patents

	Patents assigned ^a			Patents assigned ^a	
	1984 ^b	1983 ^b		1984 ^b	1983 ^b
Agrigenetics	5	1	Lever Brothers	4	2
Affromate	3	13	Eli Lilly	11	10
Baxter-Travenol Laboratories	0	3	Merck	21	25
Celltech Research Laboratories	0	0	Miles Laboratories	17	14
Cetus	0	0	Molecular Genetics	1	0
Boehringer Mannheim	2	3	Monoclonal Antibodies	0	0
Cetus	3	0	Nabisco	0	5
Collaborative Research	0	0	Novo Industri	2	3
Corning Glass Works	1	2	Ortho Diagnostics	5	1
Danisco Biotech	0	1	Pfizer	7	5
Du Pont	10	2	Phillips Petroleum	5	4
Euro Biochem	0	0	Sanofi-Sino	4	1
Genentech	5	0	SmithKline Beecham	2	2
Genex	1	1	Schleier Chemical	3	2
Green Cross	2	2	Takeda Chemical Industries	7	4
Hoffmann-La Roche	10	14	Upjohn	10	6
Hybritech	0	1	Other	423	425
Kyowa Hakko Kogyo	4	4	TOTAL	592	581

^a Biotechnology-related patents assigned by U.S. Patent & Trademark Office to U.S. and foreign-owned corporations. Selection of individually specified companies included as a cross section of industrial activity. ^b Data are for first nine months of each year. Source: OMEC International

Foreign patents may offer less protection

Despite industry's complaints about the performance of the U.S. Patent & Trademark Office and anxiety over patent uncertainties, there is a widespread belief that U.S. patent law probably will work out to protect biotechnology-related inventions better than foreign patent systems.

"It's perhaps fair to say that the patent laws in the U.S. provide for a better degree of protection in biotechnology than the laws in many other countries," says Robert C. Kline, chief counsel in Du Pont's patent division.

U.S. patent law includes a number of incentives for inventors to file for a patent application that do not exist in Japan and Western Europe. For instance, in the U.S., inventors have a one-year grace period between the time a written description of their invention is made publicly available and the date of the filing of a patent application. By comparison, the Japanese grace period is just six months, and in Western Europe there is no grace period at all.

Also, the U.S. patent office keeps a patent application secret and the inventor's culture microorganism unavailable to the public until the patent issues. In Europe, on the other hand, anyone can inspect the application (usually for 18 months) after filing, regardless of whether a patent is ultimately granted.

Another advantage of the U.S. system to inventors is that if there are several different inventors applying for a patent on the same invention at the same time, the patent is awarded to the applicant who was the first to make the invention. In Western Europe and Japan, by contrast, it is the first party to file an application that gets priority.

Perhaps most important to those who would protect their biotechnology inventions in the U.S. is the patent office's apparently broad interpretation of what is patentable. U.S. patent policy seems to allow the inclusion of plants and animal types and the biological methods for producing them. The

European Patent Convention, on the other hand, deems new plants and animal types unpatentable. Japan excludes from patent consideration inventions that involve unclear processes or methods.

"The U.S. appears to offer a competitive advantage over Europe and Japan in encouraging inventors to file for patents rather than to keep the invention a trade secret," comments the International Trade Commission's October assessment of international developments in biotechnology.

But U.S. biotechnology firms are less happy about the U.S. failure to define as patent infringement the use of a process—already patented in the U.S.—outside the U.S. by a competitor to the patentee, since the product made by this process can then be imported back into the U.S. A provision that would have amended that policy was deleted from a bill (H.R. 6286) passed by the recent Congress that included other changes in patent law.

Research, Damon Biotech, Enzo Biochem, Hybritech, and Monoclonal Antibodies, none.

Second, Zaborsky comments, universities are gaining nearly a fourth as many biotechnology patents as are U.S. corporations, a level he calls "amazingly" high. "This is a trend," he says. "More universities are patenting their faculty inventions."

The rapid proliferation of biotechnology patent applications has put

the patent office to the test, and, so far, the examiners have drawn mixed reviews from members of industry. The patent office has been criticized for slowness in processing applications and for inadequate scientific expertise on its staff of examiners.

"A lot of questions remain as to what can be defined as unique, and the [patent office] staff probably could use more people to make that

judgment," remarks Zsolt Harsanyi, a biotechnology consultant to Porton International, a British biotechnology firm, and to E. F. Hutton. "People filing applications have said to me that they're having real trouble explaining what the concept is to the people at the [patent office]. They get remarks back that to them indicate that perhaps the point was missed."

Harsanyi, in an assessment that

Japanese lead other foreign firms in biotechnology patent activity in U.S.

	Patents assigned ^a					Patents assigned ^a			
	1984 ^b	% foreign total	1983 ^b	% foreign total		1984 ^b	% foreign total	1983 ^b	% foreign total
Japan	149	45.7%	139	41.6%	Denmark	7	2.2	9	2.7
West Germany	57	17.5	47	14.1	Sweden	7	2.2	8	2.4
Great Britain	30	9.2	15	4.5	Belgium	5	1.5	0	0.0
France	19	5.8	31	9.3	U.S.S.R., Eastern Bloc	4	1.2	15	4.5
Canada	8	2.4	13	3.9	Australia	3	0.9	1	0.3
Netherlands	7	2.2	14	4.2	Austria	1	0.3	3	1.2
Italy	7	2.2	13	3.9	Israel	1	0.3	4	0.9
Switzerland	7	2.2	11	3.3	Other	14	4.3	11	3.3
					TOTAL	326	100.0%	334	100.0%

^a Biotechnology-related patents assigned by U.S. Patent & Trademark Office to foreign-owned companies. ^b Totals are for first nine months of each year.
Source: OMEC International



Harsanyi: question of uniqueness

others in the field have made as well, says that the patent office has approved patents for inventions and processes that seem obvious to those practicing the science. "I've looked at a couple of vaccine applications, and for the life of me, I can't believe how the claims were ever allowed. To me, some of the claims that were made were quite well known in the field," he says.

Well aware of such criticism, the patent office has taken a number of remedial steps, both in response to the particular complaints of the biotechnology field and as part of a broad, long-term effort to beef up performance in all areas. In the general area, the patent office is moving on three major goals—to bring the period between a patent's filing date and disposal of the application down to 18 months; to bring the pendency period for trademark applications down to 13 months; and to automate search operations by 1990.

Still, the patent office currently is working on a backlog of some 1000 applications in the genetic engineering area and 2600 in the broader biotechnology field (including genetic engineering). The average pendency for both categories has now stretched out to some 28 months, according to Rene D. Tegtmeyer, assistant commissioner for patents in the patent office. Part of the problem, Tegtmeyer explains,

is lack of staff. There are now just 26 patent examiners in the biotechnology area, with only 12 of them concentrating on recombinant DNA-based inventions. Although the patent office is planning to increase the genetic engineering examiner staff to 20 and the biotechnology total to 40 by next September, Tegtmeyer warns that it takes four to five years before examiners are fully proficient in their area.

To counter this problem, the patent office has made several organizational and procedural changes in an effort to streamline the process and improve the quality of patent examination. Previously, for instance, applications related to biotechnology were distributed among a half-dozen examining groups in the patent office. Now, almost all such patents are consolidated within two subgroups—or "art units"—of one examining group. Other changes include greater attention to training examiners and a "special status" mechanism to speed up disposal of applications that meet certain requirements. According to the patent office's Tegtmeyer, so far there has been only one request for



Price: a period of uncertainty

Academic biotechnology patent activity dominated by a handful of universities

	Patents assigned ^a			
	1984 ^b	% university total	1983 ^b	% university total
University of California ^c	15	19.2%	10	20.4%
Cornell University	5	6.4	2	4.1
Stanford University	5	6.4	2	4.1
University of Wisconsin	5	6.4	3	6.1
Harvard University	4	5.1	4	8.2
Purdue University	3	3.8	1	2.0
University of Illinois	2	2.6	0	0.0
Iowa State University	2	2.6	1	2.0
Massachusetts Institute of Technology	2	2.6	5	10.2
Montana State University	2	2.6	1	2.0
Northwestern University	2	2.6	1	2.0
Other	31	39.7	19	38.9
TOTAL	78	100.0%	49	100.0%

^a Biotechnology-related patents assigned by U.S. Patent & Trademark Office to U.S. universities. ^b Data are for the first nine months of each year. ^c Entire university system. Majority are University of California, Berkeley. Source: OMEC International

priority attention in the genetic engineering area.

Those and other measures are generally pleasing to industry. "I think the government [patent agency] is probably not moving as fast as we'd like, but at least it's moving in a pretty good direction for us on this," says John E. Donalds, president of Collaborative Research, Lexington, Mass.

But although the patent office adjustments seem a good response to the mechanical problems of biotechnology patenting, biotechnology inventors are not expecting the philosophical questions in the area to be answered quite so succinctly. The patent office has indicated that it expects the courts to settle many of the thornier debates. What those in industry, academia, and elsewhere can definitely anticipate is that much of the biotechnology patent gray area will be illuminated on a case-by-case basis.

"The issue is not really whether patent law will be adequate, but the issue is that there will be some period of uncertainty while details are being sorted out," comments Harvey S. Price, executive director of the Industrial Biotechnology Association. "Of course, it will be in the industry's interest if these things are sorted out in a shorter time frame rather than in a longer time frame." □

Fiber intermediates output stymied
by apparel imports Page 13

DECEMBER 17, 1984

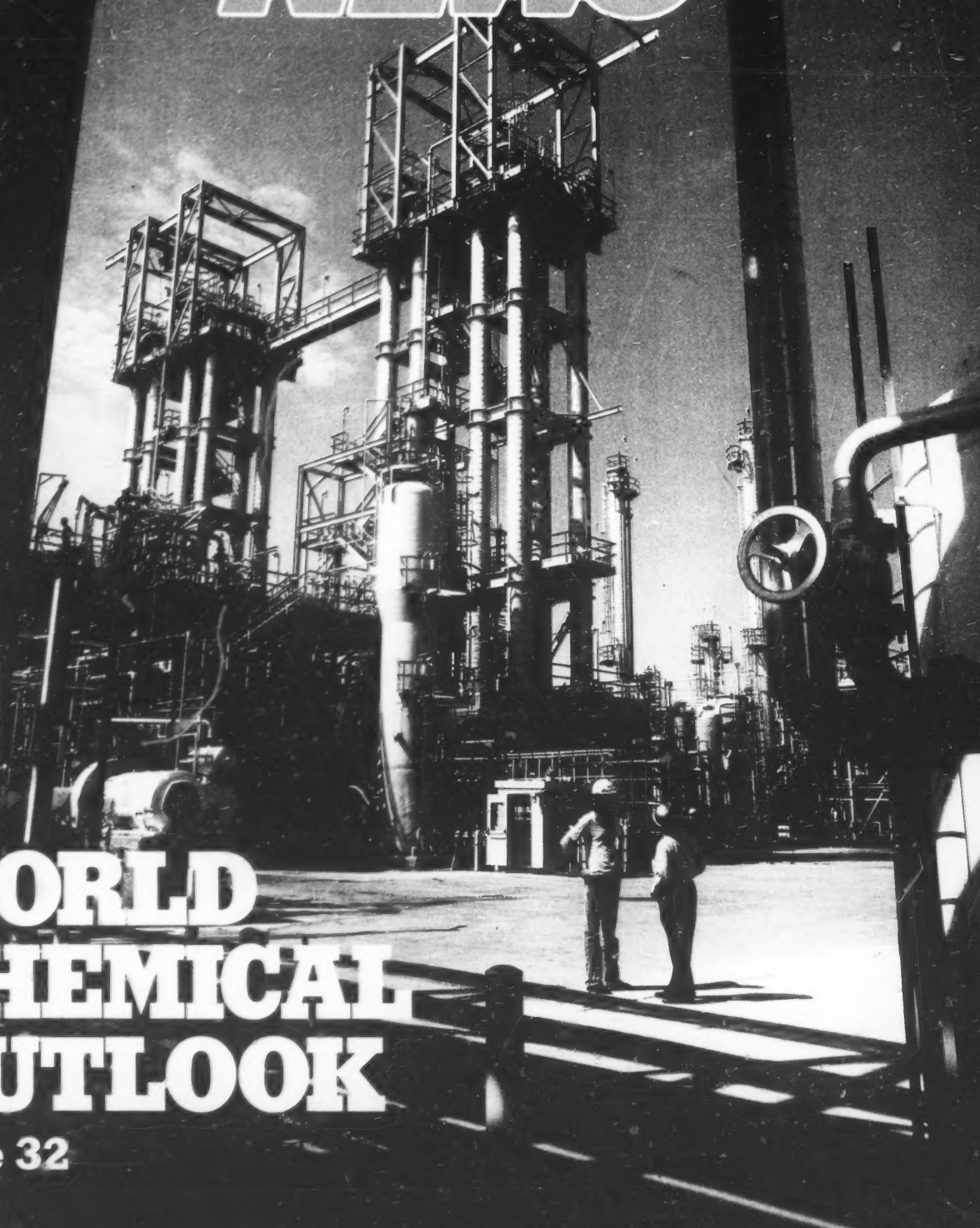
CHEMICAL & ENGINEERING

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WORLD CHEMICAL OUTLOOK

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News of the Week

■ Many questions concerning the tragedy at Bhopal remain: how the accident happened, how survivors will be compensated. **Page 6**

■ Operations at Institute, W.Va., methyl isocyanate plant shut down for safety checks; attempts made to reassure local residents. **Page 7**

■ Carbide stock price fell steeply in week following the accident; investors are concerned that damage payments will not be fully covered by insurance. **Page 7**

■ Two House subcommittees hold hearings to evaluate effect of Bhopal tragedy on U.S. **Page 8**

Cover: Solvay America's new polypropylene plant at Deer Park, Tex.

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Business

Demand for major fiber intermediates stagnates as apparel imports increase alarmingly and fiber export markets decline. **Page 13**

Biotechnology firms enjoyed higher revenues in the third quarter but costs of operating, R&D, and marketing also rose. **Page 17**

Government

Conservative Heritage Foundation report urges upgrading weapons programs, Star Wars system in future science policy. **Page 20**

Nine-member bipartisan commission to be set up to examine need for chemical arms, binary weapons in particular. **Page 22**

Federal research and development activities are not expected to suffer unduly from proposed Administration budget cuts. **Page 23**

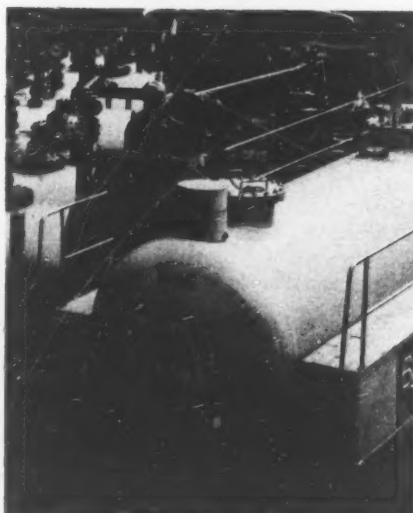
NAS's Board on Chemical Sciences & Technology will advise Army on defensive aspects of chemical and biological warfare. **Page 23**

Technology

Underground coal gasification—planned commercial project and Gulf economic model aired at AIChE meeting. **Page 25**

Commercialization of fluidized-bed method to convert methanol to gasoline close to reality after pilot plant success. **Page 27**

³⁴S-enriched sulfur produced at Oak Ridge by gas centrifugation; GE synthesizes the first gem-quality jadeite. **Page 28**



Special Report

1984 was generally a good year for the chemical industry worldwide but prospects for 1985 are mixed. **Page 32**

Apparel Imports Slow Fiber Intermediates Demand

Rising imports coupled with fall in export markets for fibers are hurting major intermediates DMT/PTA, ethylene oxide, cyclohexane

Bruce F. Greek, C&EN Houston

Changes being wrought in textile trade are playing havoc with the U.S. synthetic fibers industry. At the heart of these changes are a fast-rising tide of imported apparel and a decline in export markets for fibers and fiber precursors made in the U.S. But the impact of these changes extends to the chemical producers who make such fiber intermediates as dimethyl terephthalate/purified terephthalic acid (DMT/PTA), ethylene oxide, and cyclohexane.

The immediate impact on these intermediates, which are used to make nylon and polyester, is stagnating demand. As a result, produc-

tion is declining to the point that recovery from the recent recession has been interrupted. Of the three intermediates, only ethylene oxide is likely to top its prerecession high in production this year. And for next year, production of all three is expected to hover near that of 1984.

Longer term, there may be some hope in the form of import controls, but the outlook is far from clear. Indeed, there's no consensus that efforts to reduce imports of apparel would be successful in alleviating

were to stem apparel imports, then production of the fiber intermediates could increase in tandem with growth in domestic fiber demand, as normally influenced by such factors as fashion and population.

The outlook for the three major fiber intermediates goes beyond just textile and apparel, for their derivative fibers go into many other products as well. Carpets dominate the fibers' other uses, and for the longer term, fiber production depends partially on demand for carpets, which, in turn, is influenced by home building, home sales, and commercial space leasing. These markets are heavily influenced by the economy and interest rates.

Although fibers for apparel and carpets dominate the uses of the three fiber intermediates, each of these materials has other uses. With the exception of antifreeze, polyester bottles, and solvents, none of these other uses are very large. And with the possible exception of bottles, none will grow much during the rest of the 1980s.

With the slowing demand for the fiber intermediates, capacity, too, likely will decline. Indeed, within the next five years, the number of producers of ethylene oxide and cyclohexane is expected to shrink, because chances of restarting now shut-down plants and of regaining good profitability from operating others will be slim owing to the very slow growth for their products.

So fiber intermediates producers may be set to enter 1985 with a certain amount of apprehension. The new year may see nearly all fiber-related growth disappear, with many producers' hopes tied to a political uncertainty called import controls.

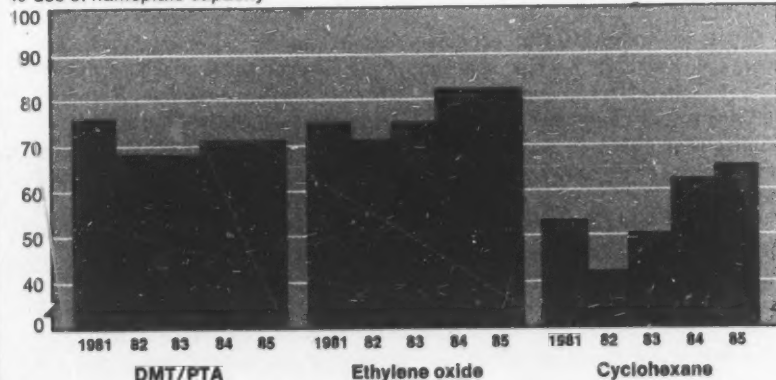
For more details on the outlook for these fiber materials, see the following pages.

Key Chemicals

the problem of depressed demand in the long term. If it should turn out that import controls in any form cannot do the job, then production of these fiber intermediates could enter a long-term decline with the usual profit drops and losses before production units are shut down. On the other hand, if import controls

Capacity use of cyclohexane plants continues to move up

% use of nameplate capacity^a



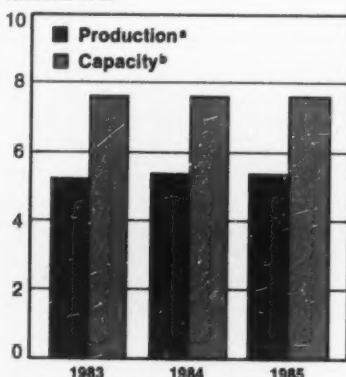
^a Capacity may be overstated because some capacity now shut down may never be restarted.
Sources: Industry and C&EN estimates, International Trade Commission

DMT/PTA

- Demand growth stopped
- Capacity on hold
- Prices discounted

PRODUCTION/CAPACITY

Billions of lb



^a DMT and DMT equivalents of PTA (1.0 lb of PTA = 1.17 lb of DMT). ^b First quarter.

MAJOR PRODUCERS

Amoco Chemicals, Du Pont, Eastman Chemical, Hercotina

HOW MADE

Oxidation of *p*-xylene and concurrent esterification with methanol to make DMT; oxidation of *p*-xylene to make PTA

MAJOR DERIVATIVES (U.S.)

Polyethylene terephthalate 90%, polybutylene terephthalate 5%

MAJOR END USES (U.S.)

Polyester fibers 70%, films 10%

FOREIGN TRADE

Exports—may exceed 200 million lb in 1984, imports—negligible

PRICES

List prices about 35 cents a lb for DMT and 39 cents a lb for PTA

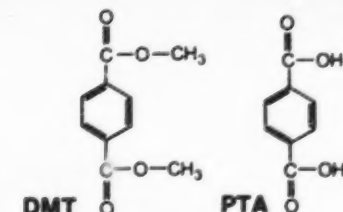
Dimethyl terephthalate (DMT) and purified terephthalic acid (PTA) have clearly lost their status as two of the premier growth products of the chemical industry. These products of the oxidation of *p*-xylene now have joined the growing group of chemicals afflicted with sizable overcapacity, slowing total exports, and softening domestic demand. Production in 1985 will do well just to match that of 1984: about 5.4 billion lb for DMT and PTA converted to DMT equivalents.

At 5.4 billion lb, this year's production will end up just 4% higher than the disappointing output of 5.2 billion lb in 1983. This less-than-forecast production growth in both 1983 and 1984 means that topping 1981's previous production high of 6.1 billion lb could remain several years away. Some industry sources even refuse to predict when former production highs will be matched, because the outlook for polyester fibers, films, and bottles is clouded by such uncertainties as the future level of apparel imports and the untested market potential of plastic half-liter soft drink, beer, and other beverage bottles.

With growth expectations for the polyester segment so uncertain, little new investment is going into production equipment. Other than for minor debottlenecking that will raise nameplate capacity no more than 1%, capacity to make DMT/PTA will remain at about 7.6 billion lb for at least several years to come.

What this means is that capacity utilization rates likely will hold at about 67% for some time to come. At that utilization rate, operations are barely profitable—far less so than in 1981, when plants ran at 80% of nameplate capacity.

The forecast of continued low operating rates means that there will continue to be heavy pressure on prices in DMT/PTA's merchant market. Discounting of list prices apparently has increased some this year, partly because consumers know that the price

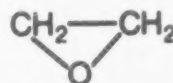


of *p*-xylene has declined along with that of other petroleum products. DMT/PTA buyers want any savings passed along to them.

Almost all DMT/PTA goes into polyesters, predominantly polyester fibers. Thus, DMT/PTA's slow or even flat growth pattern ultimately stems from the slowdown in demand for U.S.-produced polyester fibers. That development, in turn, is the consequence of lower fiber export volume and a higher level of imports of garments made with polyester fibers. Aggravating the impact of the reduction in fiber exports is a drop in exports of polyester in chip form from which fibers are spun. As might be expected, the strong dollar is an incentive for foreign polyester chip producers to export their product to countries in which the garments eventually exported to the U.S. are made.

Compounding these problems, a secondary market for some forms of polyester fibers has begun to cut into primary production. One example is the recycling of polyester resin used in plastic bottles into filler material for insulated clothing and sleeping bags and for reinforcement in unsaturated polyester resin-fabricated products. Laws requiring a cash deposit on many beverage containers—so-called "bottle laws"—are being enacted in more and more states, increasing the incentive to recycle. As a result, more new, small companies are in the business of producing fiber materials from used bottles. So far, however, there is no clear quantitative estimate of the effect of recycling on primary polyester production and DMT/PTA demand.

Even with some growth in demand for polyester fibers, film, and bottles in the U.S., the offsetting impact of such factors as apparel imports and plastic bottle recycling pushes forecasts of DMT/PTA down to new low levels. At best, assuming there is no serious recession, demand for DMT/PTA next year will just match demand in 1984.

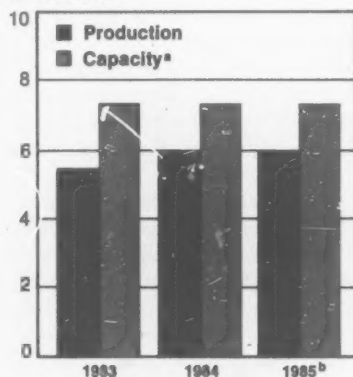


Ethylene Oxide

- Demand on hold
- Capacity declining
- Prices down

PRODUCTION/CAPACITY

Billions of lb



^a First quarter. ^b Some capacity down, may never be restarted.

MAJOR PRODUCERS

BASF Wyandotte, ICI Americas, Shell Chemical, Texaco Chemical, Union Carbide

HOW MADE

Vapor-phase oxidation of ethylene with air or oxygen

MAJOR DERIVATIVES (U.S.)

Ethylene glycol 60%, ethoxylates 10%, glycol ethers 5%

MAJOR END USES (U.S.)

Polyester fibers, films, and molded items 30%; antifreeze 25%

FOREIGN TRADE

Exports—small, probably less than 25 million lb for 1984, imports—probably less than 10 million lb for 1984

PRICES

For merchant sales less than 10% of total output, about 35 cents per lb

Demand for ethylene oxide is being undermined seriously by a flood of imports of finished products containing the materials that make up the chemical's most important end-use markets. Producers of ethylene glycol—by far the most important derivative of ethylene oxide—are seeing both domestic and overseas demand for its two chief consumers, polyester fibers and antifreeze, undercut by imports of polyester garments and foreign-made autos containing factory-installed antifreeze.

As would be expected, weakening demand has reduced capacity utilization rates and will continue to do so this year. Production in 1985 will do well to match that of 1984. Prices are under pressure, especially since ethylene prices remain soft.

If the economy continues to grow next year at the 1984 rate, 1985 production of ethylene oxide probably will total 6 billion lb, the same volume expected for 1984. Since some producers expect demand to decline in second-half 1985, however, some growth will be needed in the first six months to reach the 1984 level. Such a scenario would recapitulate 1984's pattern of production; output rose well in the first half of the year before apparently slumping, destroying chances for meeting optimistic forecasts made in the spring.

Ethylene oxide capacity may seem excessive if just the total is considered. However, nearly 1 billion lb of nameplate capacity probably will be shut down during most of 1985. Earlier this quarter, both Dow Chemical and Union Carbide disclosed that they will place ethylene oxide plants on standby. Whether those units are restarted will depend greatly on the overall economics of production and consumption ranging from ethylene feedstock costs to the level of competition with imported ethylene glycol and finished goods containing ethylene oxide derivatives.

With about 920 million lb of capacity down next year, the average operating rate could be a quite healthy 94%

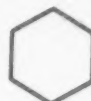
of the roughly 6.4 billion lb of nameplate capacity that actually will be running. Taking the total industry nameplate capacity of 7.3 billion lb, however, the rate falls to 82%. That is a clearer indication of the position in which ethylene oxide producers now find themselves. Moreover, that estimate of potential nameplate capacity could be understated, because some producers have slowly been debottlenecking plants and adding process improvements in an effort to increase profitability. The additional capacity probably does not exceed 3% more, however, so the industry total is 7.5 billion lb at most.

Good performance by ethylene glycol, which accounts for more than 60% of ethylene oxide consumption, remains the key to achieving these operating rates. Demand from each of ethylene glycol's three major uses—polyester fibers, antifreeze, and exports—is expected to decline from current levels because of foreign competition. Although other ethylene glycol uses—as a solvent and in de-icing fluids, for instance—are affected little by the vagaries of international trade, their potential growth is considered small.

There is a wide spectrum of other end uses of ethylene oxide and its derivatives. One, glycol ethers, may lose its market in paints and other solvent applications to propylene oxide derivatives in coming years because of toxicity concerns. Other derivatives, such as ethanalamines and ethoxylates, eventually end up used in natural gas scrubbing and surfactants.

For ethylene oxide, the outlook over the near term seems to be for profitless, high operating rates as a result of reduced capacity. But 1985 also could be the year in which U.S. producers get a much better idea of how great an impact foreign competition will have on them. That would give some indication of what will happen in the future to domestic capacity that is still running.

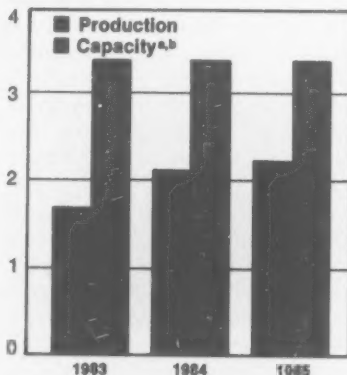
Cyclohexane



- Demand recovered
- Capacity may fall
- Prices down

PRODUCTION/CAPACITY

Billions of lb



■ Some capacity down and may not restart. ■ First quarter.

MAJOR PRODUCERS

Du Pont, Gulf Oil Chemicals, Phillips Chemical, Texaco Chemical, Union Oil

HOW MADE

Catalytic hydrogenation of benzene; recovered from natural gasoline

MAJOR DERIVATIVES (U.S.)

Adipic acid 60%, caprolactam 30%

MAJOR END USES (U.S.)

Nylon 66 60%, nylon 6 30%

FOREIGN TRADE

Exports—rising, may reach 150 million lb in 1984, imports—very small, may reach 25 million lb in 1984

PRICES

List prices follow benzene prices closely; now at \$1.28 per gal

Cyclohexane production this year has been rising and falling like a roller coaster. After a slow start in the first three months of 1984, output climbed fast in the second quarter, only to slow drastically in the third. This unusual variation in the production pattern was partly the consequence of changes in demand for nylons—which account for practically all of cyclohexane's end uses—and partly the consequence of plant problems experienced by some producers early in the year.

As a result, forecasting total production for the year is more or less guesswork. Probably, cyclohexane output will top 2 billion lb, possibly 2.1 billion lb. Although not a record by far, that total still would represent the best production year of the 1980s. Next year, if all goes reasonably well with the economy and interest rates hold or rise only modestly, a slight increase in production would bring the total to 2.2 billion lb.

The vagaries of 1984 production levels can be seen clearly in data reported by the U.S. International Trade Commission. Monthly output started at 140 million lb in January, rose to 181 million lb in February—despite 6% less production time—and then ballooned to 270 million lb in March. Because of plant problems, output fell off in April, and, in May, was back down under 160 million lb. By July, production had reascended to 236 million lb, before plunging again to 140 million lb and 145 million lb in August and September, respectively. Guesses are that in the fourth quarter output has been quite low, possibly at the lowest monthly levels of the year.

Cyclohexane producers have had no trouble handling demand at the peaks of their roller coaster ride, because there is plenty of excess capacity. Of the nameplate capacity available as 1984 began, nearly 10% was down temporarily, and during most of the year that fraction of capacity has not been running. During a siege

of plant problems that began late in the first quarter, about half the remaining capacity was down for an average time of one month. Thus, total 1984 nameplate capacity for the cyclohexane industry includes more than 400 million lb that was not producing during the year—about an eighth of the total.

Even with an eighth of capacity inactive, cyclohexane producers still will operate their plants at no better than an average 70% of operable capacity for the year. Based on nameplate capacity, the average utilization rate falls to less than 62%. The erratic nature of the year shows up in monthly changes in utilization rates, however, ranging from more than 100% to less than 54% of active capacity.

Those wide swings in production and operating rates haven't affected prices significantly. The cyclohexane price is very closely tied to that of benzene, and consumers are quick to insist that a decline in the benzene price be passed on to them when it occurs. Because of the large average overcapacity for cyclohexane, producers have little leverage with which to loosen the connection to benzene pricing.

Demand for cyclohexane will closely track demand for apparel and carpet uses of nylon 66 and nylon 6. Since imports of both nylon fiber and apparel are rising rapidly, domestic fiber consumption will do little anytime soon to increase demand for U.S.-produced cyclohexane. The use of nylon as an engineering resin keeps growing faster than the gross national product, but volume is still too small to create sales that would significantly increase demand for cyclohexane. Cyclohexane's solvent and chemical intermediate uses are also small and not growing much.

During 1985, cyclohexane producers will continue to struggle with excess capacity while hoping that nylon will return to better times. A small production gain might occur, but it won't do anything for profitability.

Biotechnology revenues, costs surged in third quarter

David Webber, C&EN New York

Thanks to blossoming product sales in some cases, lucrative research contracts in others, and still-healthy interest income in nearly all, the revenues of biotechnology-based companies surged again in the third quarter. For a group of 14 companies representing a cross section of the biotechnology-based industry, composite revenues increased 99% following a 92% jump in the second quarter of the year.

At the same time, however, the size of the group's composite net loss for the quarter more than doubled to \$9.3 million from \$4.2 million in third-quarter 1983. This was primarily the consequence of sharply higher operating costs and expenses for research and development, manufacturing, marketing, and administration at many of the firms in the group.

Amgen, for example, spent 75% more during the six months ending Sept. 30, 1984, than in the same period last year, reflecting a higher rate of investment in new product and new process development, the company says. As a result, the six-month loss stretched from \$2.5 million in 1983 to \$4.1 million this year. At Biogen, expenses for the quarter jumped to \$11 million from \$7.8 million last year. At California Biotechnology, R&D costs grew 77% over the first nine months of 1984. At Damon Biotech, R&D spending increased 78% for the fiscal year ending Aug. 31. At Genentech, total costs and expenses rose 46% in the third quarter.

The rise in expenditures was not unexpected. Each firm in the group is spending substantial amounts of money to make the transition from research boutique to integrated manufacturing entity. There are a number of cash-consuming chores involved in effecting that change, ranging from bolstering marketing staff to building plants to carrying R&D costs alone—as opposed to sharing them with licensees—in order to retain sole rights to a product.

"This growth in research costs reflects increased commitments to our

proprietary projects," notes California Biotechnology chairman Alfred G. Scheid in a typical explanation.

The effort to make this transition has created a requirement for extra delicacy in the management of each firm's financial resources. For a long time, many of the small biotechnology-based companies were able to leave relatively untouched the mounds of cash they amassed from stock issues, private equity sales, and other financial devices during the past several years. Having reached this stage in their evolution, however, many have now begun to dig into those mounds.

This has had a noticeable impact on the financial condition of some of the firms. Current ratios (the ratio of current assets to current liabilities: the higher the ratio, the stronger a company is judged in terms of its ability to meet its short-term obligations) are falling from the stratospheric heights of the past to more mundane levels. For example, in comparisons of the present value of the financial measurement to where it was at the beginning of 1984, Centocor's current ratio has fallen to 7.5 from 10.8; Genex's to 3.7 from 6.6; Hybritech's to 5.2 from 14.8; and Monoclonal Antibodies' to 2.3 from 15.6. Cetus' current ratio declined to 17.1 at the end of the third quarter from 25.8 at the end of the second quarter of 1984.



Scheid: growth in research costs



Gilbert: belt-tightening steps taken

For the most part, it is important to note, these measurements still indicate robust financial condition. The average current ratio for the chemical industry, by comparison, is typically around 2.0 (although it fell below that in 1982 and 1983). (As a rule of thumb, a ratio of 2.1 or greater is considered good for mature companies.) And in some cases, the financial condition of biotechnology-based firms has improved. Amgen's current ratio rose to 22.7 at the end of the third quarter from 19.1 at the end of the first quarter of the year, and Molecular Genetics' leaped to 48.0 from 12.8 at the beginning of 1984.

The difficult decisions involved in depleting those piles of cash and thus becoming financially more vulnerable are even more anxiety-making because the chances of many of the biotechnology-based companies finding ready financing, should the need arise in the near future, are considered much worse now than they were the first time these firms approached the investment community. For one thing, biotechnology stocks have almost uniformly declined in 1984. Some have reached all-time lows in recent months.

The difficult task of keeping the

Biotechnology revenues increased 99% in third-quarter 1984

	FIRST-QUARTER 1984 ^a						NINE-MONTHS 1984 ^b					
	Revenues ^c	Earnings ^d	Change from 1983		Profit margin ^e		Revenues ^c	Earnings ^d	Change from 1983		Profit margin ^e	
	(\$ millions)		Revenues	Earnings	1984	1983	(\$ millions)		Revenues	Earnings	1984	1983
Advanced Genetic Sciences	\$ 0.02	\$-1.68	-96%	def	def	def	\$ 0.12	\$-5.21	-93%	def	def	def
Amgen	2.55	-2.04	34	def	def	def	na	na	na	na	na	na
Applied Biosystems	6.83	1.22	110	160%	17.9%	14.4%	17.73	3.22	na	nm	18.2%	na
Biogen	8.19	-2.76	56	def	def	def	22.01	-10.92	48	def	def	def
California Biotechnology	2.04	-0.12	53	def	def	1.6	6.11	0.01	77	-91%	0.2	3.6%
Centocor	3.51	0.24	65	40	6.7	7.9	8.75	0.35	74	-51	4.0	14.2
Cetus	20.61	0.38	108	28	1.8	3.0	46.31	0.68	75	nm	1.5	def
Damon Biotech	1.04	-1.85	1	def	def	def	3.96	-2.51	84	def	def	def
Genentech	19.09	1.10	50	223	5.8	2.7	51.65	2.11	54	134	4.1	2.7
Genex	19.30	-3.20	537	def	def	def	33.53	-6.82	421	def	def	def
Hybritech	8.38	0.30	97	3	3.6	6.9	22.46	0.70	107	nm	3.1	def
Molecular Genetics	2.29	0.05	17	-79	2.3	12.9	7.12	0.01	43	-98	0.1	8.0
Monoclonal Antibodies	1.11	-0.85	242	def	def	def	2.93	-2.50	231	def	def	def
Ribi ImmunoChem	0.27	-0.05	54	def	def	def	0.75	-0.19	52	def	def	def

a For three-month period ending closest to Sept. 30. b For nine-month period ending closest to Sept. 30. c Includes sales, contract research, royalty, and interest revenues. d Excludes extraordinary credits. e After-tax income as a percentage of revenues. na = not available. nm = not meaningful. def = deficit.

expense of the transition to manufacturing company in line with resources already is beginning to force retrenchment of one sort or another at a number of biotechnology-based firms. For instance, earlier this month Genex decided to eliminate 54 research and administrative positions, or about 16% of its total workforce. The Rockville, Md., company, generally considered one of the half dozen "leaders" to come out of the biotechnology startup spree, has seen its cash position weakened considerably in 1984: Current assets shrank from \$30.2 million at the beginning of the year to just over \$17 million at the end of September, largely a factor of unexpectedly high startup costs for its Paducah, Ky., L-phenylalanine facility.

On first glance, seven-year-old Genex appears to be coming off an exceptionally strong quarter. Third-period revenues more than quintupled to \$19.3 million, including \$10.7 million in product sales. But the company notes that unique circumstances make it difficult to predict future results from the data. Third-quarter sales were far higher than anticipated, Gene says, and probably will be substantially lower in the final three months of the year. Furthermore, \$6.9 million of the revenue total represents a one-time gain stemming from an agree-

ment with Allied to terminate two R&D projects with Allied subsidiary Bendix.

In a similar move to control expenses, Biogen has cut staff by 56 positions, or 13% of the total, half in the U.S. and half in its Geneva, Switzerland, headquarters. "We have taken steps to correct for overstaffing that developed during our rapid expansion over the past two years," says Walter Gilbert, chairman of the company. "This belt-tightening will ensure that the growth in expenses in the near term will be moderate. It will not affect the timing of our products coming to market."

In a different example of the financial ramifications of making a transition, Advanced Genetic Sciences is taking the risk of severely pruning its R&D contract activities—its chief sources of revenues—in order to concentrate on proprietary research. The immediate consequence of this ongoing program has been a steep reduction in revenues and an increase in losses. In the third quarter of 1984, revenues totaled just \$23,204, compared to \$576,766 in the same period last year. The company's net loss for the quarter nearly doubled to \$1.7 million.

"This is consistent with our strategic decision made some years ago to become a fully integrated manufacturing and marketing company

based on products developed in our laboratories and the related decision not to enter into additional research contracts except on a very limited basis with our shareholders," comments Daniel D. Adams, AGS's chairman and chief executive officer. "We believe such contracts interfere with our business development and in general are not profitable."

Several companies—still primarily those selling monoclonal antibody-based diagnostic products or instrumentation, reagents, and other supplies to the biotechnology market—continue to report sharp increases in product sales. For example, Hybritech, which is focused in monoclonals, recorded a 79% increase in product sales to \$3.4 million in the third quarter. Over the nine-month period, the company's product sales more than doubled to over \$9.5 million.

Hybritech's competitor, Monoclonal Antibodies—against which Hybritech currently is pressing a patent infringement suit—also recorded a steep rise in product sales: up 171% in the third quarter to \$880,282. And Molecular Genetics, the sole product of which is a monoclonal antibody preventative for *Escherichia coli* scours in newborn calves, had a 604% gain in product sales to \$936,815 for the first nine months of 1984. □



UNITED STATES

Business is likely to improve further, but next year's gains will be slimmer than those of the past two years

David M. Klefer, C&EN Washington

After a sharp rebound, expansion slows for the chemical industry

For the U.S. chemical industry—which started 1984 with 12 months of sparkling growth in output behind it and profits rising dramatically—the past year has been something of a disappointment. It is true that for industrial chemical firms, production and sales this year will be a solid 7% higher than last year and that earnings will be up a sharp 40 to 50%.

But most of the year-to-year improvement occurred during the early part of the year. During the first six months, for example, net income was nearly 70% higher than in the year before; during the second half, on the other hand, profits are just 15 to 20% higher. Meanwhile, production of basic chemicals and synthetic materials (including plastics, fibers, and rubber), which at the start of the year was running nearly 20% above year-earlier levels, at present essentially is no higher than it was last January—or, for that matter, than at the start of 1980. And with demand still well below plant capacity, selling prices for industrial chemicals, too, have weakened slightly since mid-1984.

The recent leveling off in operations in the chemical industry reflects, to a large degree, a similar trend throughout much of the U.S. economy. Gross national product, up

10% in the first quarter and 7% in the second quarter of 1984, posted a gain of less than 2% in the third quarter. And the current quarter is expected to show no stronger increase. The Commerce Department's index of leading indicators, designed to be a harbinger of broad economic trends, was sharply lower in October. And housing starts, new orders for manufactured goods, and several other economic measures have been declining during the past few months.

As the year closes, nevertheless, executives of U.S. chemical companies remain optimistic regarding the outlook for business in the near future. A recent survey of its members by the Chemical Manufacturers Association, for instance, finds that they expect healthy increases in both sales and profits in 1985, although not up to this year's pace. Analysts outside the industry likewise expect business to be better for chemical producers next year.

But it also is clear that industry executives' optimism now is much more guarded than it was a year ago. Edwin C. Holmer, president of Exxon Chemical, noted recently, for example, that "it appears that recovery in the petrochemical sector has run out of steam," with profit margins sharply lower. No matter what happens in the rest of the industry, he thinks that earnings from petrochemicals will be down next year.

Prospects for the chemical industry in 1985 hinge, of course, on how well the overall economy fares. And on this issue, economic opinion is divided at present. The majority opinion among business analysts is that the current stint of slow growth does not indicate that the expansion

of the past two years is now grinding to a halt. Rather, they see it only as a short-term pause before another round of somewhat brisker gains, at least during the first two or three quarters of 1985. With inflation seemingly in check, interest rates trending downward, and ample productive capacity available, they argue that the economy has ample resources to maintain steady growth during the immediate future.

Few expect to see a repeat during the current recovery of the hyperactive expansion that marked the latter part of 1983 and the first half of this year. But the consensus is that real gross national product will increase at an annual rate of 3 to 4% during the first two quarters of 1985, and then will continue to grow, although more moderately, at least through the end of the year. Consumers still appear to be in a confident, money-spending mood, capital spending by industry is on the upswing, credit is not tight enough yet to choke off expansion, and inventories do not seem excessive.

But by no means are all economists so confident. The huge federal budget deficit worries many, as does the U.S.'s large and growing trade deficit. Money flowing abroad to pay for imports is money lost to domestic producers. Some argue, in fact, that the recovery already is dragging to an end and that the economy will be in recession before the winter is through. According to Roger Williams, an economic consultant in Orangeburg, N.Y., for one, "We must recognize that somewhere in the current quarter the downturn in the economy began." Williams expects recession to last at least through the third quarter of 1985.

Whatever prognostication proves correct, it is clear now that demand is easing in the chemical-consuming segments of the economy that fueled the chemical industry's growth in 1983 and 1984. Nearly all major chemical markets have been surprisingly healthy during the past year or two. But it is increasingly difficult to find areas with potential further growth in demand.

The automobile industry is one example. For much of this year, the industry's biggest problem has been to turn out enough cars to satisfy customers. During the 1984 model year, sales were up 18% (to 10.4 million cars) and, with imports' share of the market declining slightly, sales of U.S.-produced autos increased 22% to 7.9 million. Demand, moreover, still is strong and supplies are low, even tight for some popular models.

As a result, U.S. assembly lines are producing at a near-capacity clip; output during the current quarter is scheduled at close to 2 million cars, the highest for any fourth quarter since 1978. And for the year as a whole, output of U.S. cars probably will total 7.8 million, 15% more than in 1983 and at the highest level since 8.4 million units were completed five years ago.

The auto industry is looking for continued strong sales again next year, perhaps running as high as 10.7 million cars. But that would translate into a growth in output of only about 2 to 5%. Consequently, automobiles are likely to provide a good market for chemical products during the next 12 months, but not really a growth market.

Housing is another outlet for chemicals where prospects for further growth seem limited. After a sharp increase in new housing starts last winter, activity gradually has dwindled, stifled in part by rising mortgage interest rates during the spring and summer. Housing starts this year probably will total between 1.7 million and 1.8 million, only slightly higher than in 1983. Mortgage credit has become less costly in the past few months. But unless it continues to ease considerably, which few analysts expect, new home building is unlikely to grow further again in 1985.

Demand for agricultural chemicals

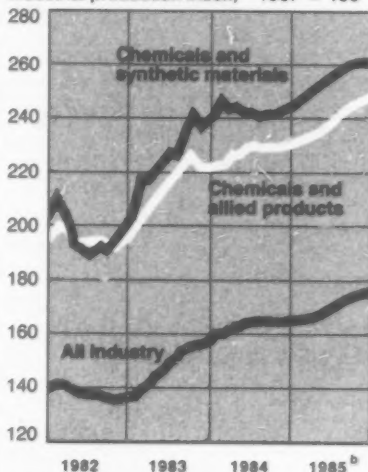
is one area that has made a strong comeback this year, after being crimped in 1983 by the government's payment-in-kind program to reduce surpluses, which took a lot of land out of cultivation, and poor weather. According to estimates by Continental Illinois National Bank, as farmers boosted their acreage this year they also increased their spending on fertilizers more than 20%. And favorable weather also has brought higher demand for pesticides and other farm chemicals. Total

production of agricultural chemicals this year probably will top last year's output 12 to 13%, and demand continues strong for fertilizer materials, both in domestic and export markets, during the latter part of the year.

This growth is likely to slacken next year, however. A sharp increase in crop production this year has depressed prices and undercut farmers' income, for one thing, with little or no improvement expected next year. And the Department of Agriculture predicts that acreage planted in major

Output of chemicals will be up moderately next year . . .

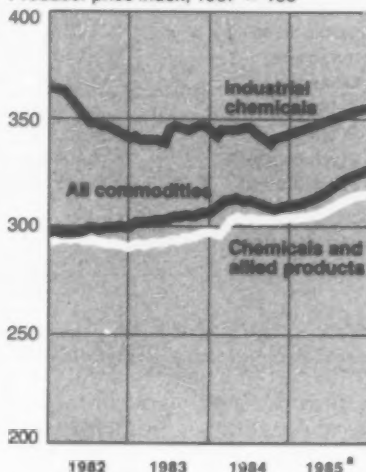
Industrial production index,^a 1967 = 100



^a Seasonally adjusted. ^b C&EN estimates. Source: Federal Reserve Board

. . . and selling prices will be a bit higher . . .

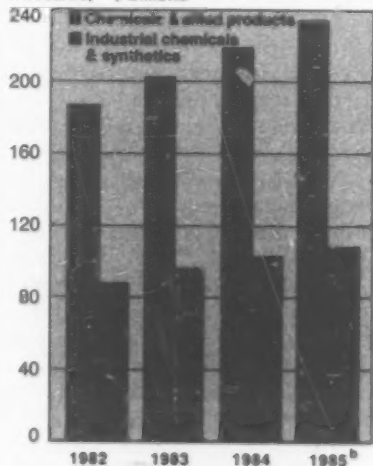
Producer price index, 1967 = 100



^a C&EN estimates. Source: Bureau of Labor Statistics

. . . so industry's sales will rise for third year . . .

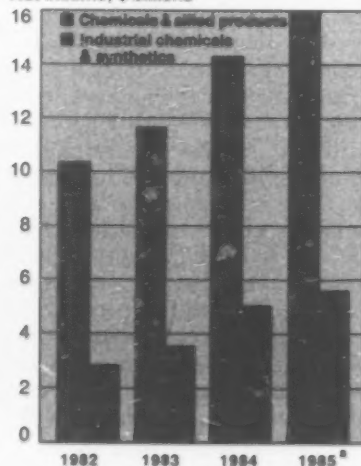
Net sales,^a \$ billions



^a Excludes sales of foreign subsidiaries. ^b C&EN estimates. Source: Bureau of the Census

. . . and its earnings will continue to recover

Net income, \$ billions



^a C&EN estimates. Source: Bureau of the Census

Production of chemicals will rise in 1985, but the gains will be smaller than this year's

	1982	1983	1984	1985
INORGANIC CHEMICALS				
Thousands of tons unless otherwise indicated				
Ammonia	15,776	13,683	16,000	16,600
Chlorine gas	9,176	9,960	10,800	11,300
Hydrochloric acid	2,460	2,608	2,850	3,000
Nitric acid	7,390	7,373	8,000	8,350
Oxygen, billions of cu ft	349	347	385	410
Phosphoric acid	8,262	9,950	11,000	11,500
Sodium hydroxide	9,385	10,230	11,100	11,600
Sulfuric acid	32,680	34,725	38,900	40,400

ORGANIC CHEMICALS

Millions of lb unless otherwise indicated

Acetic acid	2,748	2,807	2,800	3,000
Acetone	1,694	1,859	1,860	2,000
Acrylonitrile	2,035	2,146	2,250	2,400
Benzene, millions of gal	1,052	1,233	1,400	1,500
Butadiene	1,915	2,353	2,600	2,700
Cumene	2,743	3,345	3,350	3,500
Cyclohexane	1,275	1,656	2,100	2,200
Ethylene	24,501	28,680	32,200	34,800
Ethylene glycol	4,309	4,425	4,900	5,150
Formaldehyde	4,817	5,465	5,800	6,000

	1982	1983	1984	1985
Methanol	7,555	7,982	9,500	9,000
Phenol	2,023	2,638	2,750	2,900
Phthalic anhydride	684	838	925	975
Propylene	12,535	13,959	15,700	17,000
Styrene	5,942	6,802	7,700	8,100
o-Xylene	802	781	770	820
p-Xylene	3,391	4,114	4,250	4,500

PLASTICS

Millions of lb

Polyethylene, high density	4,928	5,707	6,100	6,500
Polyethylene, low density	7,503	8,045	8,350	8,700
Polypropylene	3,477	4,464	5,000	5,300
Polystyrene	3,191	3,606	3,900	4,050
Polyvinyl chloride	5,326	6,152	6,600	6,750

SYNTHETIC FIBERS

Millions of lb

Acrylic and modacrylic	624	670	680	650
Nylon	1,927	2,419	2,400	2,300
Olefin and vinyon	723	906	970	1,000
Polyester	3,169	3,544	3,350	3,250

Sources: Bureau of the Census, International Trade Commission, Society of the Plastics Industry's Committee on Resins Statistics, Textile Economics Bureau, C&EN estimates (for 1984 and 1985)

crops in 1985 will increase little, if at all. It estimates, therefore, that use of fertilizer will be up only about 2% in the farm year ending next June and that application of pesticides will show little or no gain.

One major market for chemical products that clearly is being crimped during the closing months of 1984 is textiles. Shipments of noncellulosic fibers during the third quarter were 5% lower than in the previous quarter or in the corresponding quarter of 1984, according to data from the Textile Economics Bureau. Much of the blame falls on rising imports of both fibers and textiles. At the same time, abundant cotton supplies and fashion trends that favor natural fibers over synthetics, especially polyesters, have sapped U.S. consumption. And the strength of the U.S. dollar relative to foreign currencies has cut severely into demand from overseas.

Although the impact of rising imports probably is most apparent with man-made fibers, competition in U.S. markets from abroad also is a factor increasingly cutting into demand and depressing prices for a broad range of U.S.-made chemicals. Im-

ports of chemicals of all types will increase close to \$3 billion (about 25%) this year. In addition, the rapidly widening U.S. trade deficit in other manufactured products—whether they be textiles, motor vehicles, electronic products, or appliances—indirectly but markedly diminishes U.S. chemical sales.

At the same time, the strength of the dollar has been a persistent problem in another way. Foreign subsidiaries are significant contributors to the earnings of most U.S. chemical producers, but recent gains in overseas operations have been offset, financially, when local results are translated into dollars. This problem is especially acute for U.S. drug companies, which typically get 30 to 40% of their sales and income abroad.

The pharmaceutical business also has been adversely affected by a more competitive marketplace, caused in part by efforts of the federal government to contain medicare-related hospital expenses and by the expiration of patent protection on some major drugs. As a result, the industry is likely to chalk up relatively modest (for it) increases

about 7% in sales and 10% in profits this year. Next year, especially if the dollar weakens (as many observers predict) and overseas results correspondingly improve, drug makers probably will do a bit better.

For producers of industrial chemicals, too, 1985 looks reasonably good. Production, C&EN estimates, will be 4 to 5% higher than this year, although most of the increase will take place during the first half. Competition will keep selling prices under pressure, so on average they probably will be only 1 to 2% higher than this year. That means that sales will rise about 5 to 8%, approximately the same as this year. But as also has been the case this year, manufacturing costs are likely to be under control. Reflecting stable to lower world energy prices, raw material costs, especially for petrochemicals, will be little changed. And labor costs probably will rise only modestly.

All of which adds up to an increase in profits that, although not nearly so great as this year, may well be in the range of 10 to 15%. Putting that gain into perspective, profits next year from industrial chemicals will be just about what they were in 1981. □



FOREIGN TRADE

Chemical exports are up nicely, but growth in the U.S. economy leads to an even bigger surge in imports

Earl V. Anderson, C&EN New York

World trade has always been important to the U.S. chemical industry. Now, it figures to become even more important—for all the wrong reasons.

However, until recently, world trade has never meant much in the life of the average American. Now, it is becoming much more important—again, for all the wrong reasons.

The burgeoning U.S. trade deficit has become a widespread concern. After hitting \$69.4 billion last year, the trade deficit will climb to a staggering \$130 billion or more this year.

These figures are based on U.S. imports calculated by the cif method, which includes the cost of freight and insurance. Their impact is undeniably dramatic. On the more conventional "customs" basis for tallying U.S. imports, the trade deficit this year will be "only" \$113 billion, compared to \$57.5 billion last year.

These lower numbers are little consolation. The direction in which world trade has been, and is, headed holds some serious consequences for the U.S. chemical industry, and

Strong dollar crimps surplus in U.S. trade in chemicals

for the entire U.S. and world as well.

For the U.S., international trade and the domestic economy are becoming ever more closely interrelated. The U.S. economy has been on a roll this year. Economic recovery has been faster and stronger in the U.S. than anywhere else in the world.

That fact alone would be reason enough to expect a boost in imports. But, because the dollar has remained surprisingly strong relative to major foreign currencies, U.S. imports have soared. They probably will end the year at a record \$330 billion, 28% higher than last year.

You have to go back to 1974 to find an annual advance higher than that. Then, the sudden jolt to the cost of importing oil accounted for

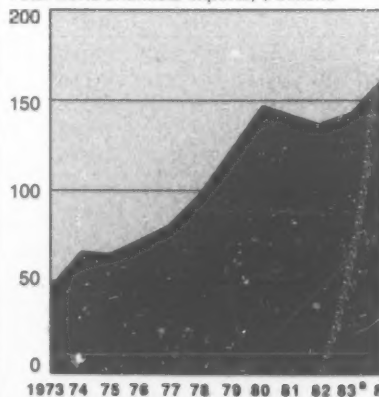
the big jump in imports. This year, the increase in the oil-import bill accounts for less than 10% of import growth. Now, manufactured products are swelling the import total.

The strong dollar has had an undeniably adverse impact on the U.S. trade balance. It also is a key link between international and domestic economics. The stronger the dollar, the less expensive imports become for the American consumer. Thus, the strong dollar, along with a growing U.S. economy, explains the import surge.

Conversely, the stronger the dollar, the more expensive U.S. exports become on world markets. That makes it difficult for U.S. manufacturers to compete in international trade. It is no surprise, there-

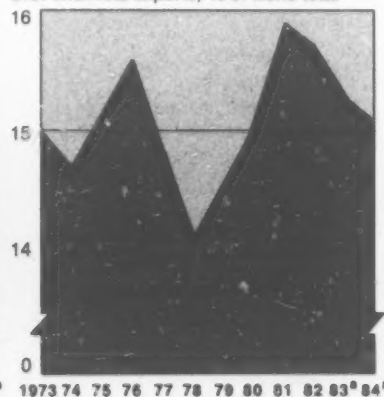
World trade rebounds smartly this year . . .

Total world chemical exports, \$ billions



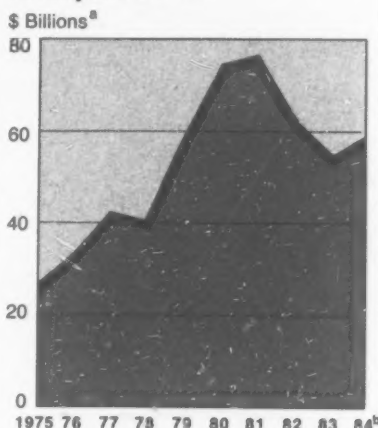
. . . but share held by U.S. continues to decline

U.S. chemical exports, % of world total^b

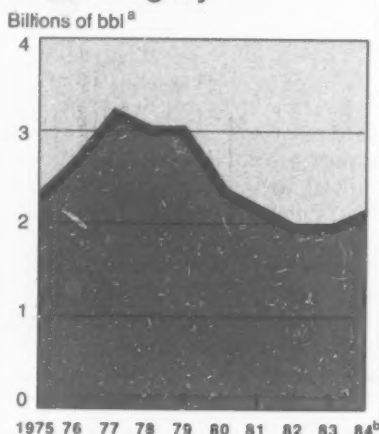


^a C&EN estimates. ^b Defined as: U.S. chemical exports as per cent of world chemical exports less U.S. chemical imports. Sources: United Nations, Bureau of the Census

U.S. spends a bit more to import oil ...

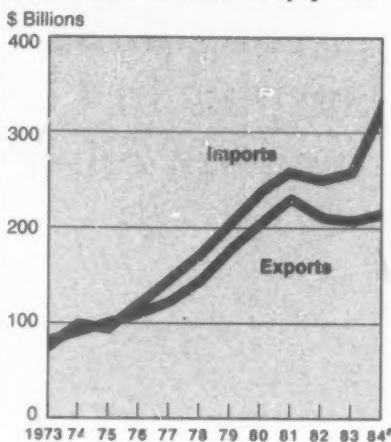


... as volume of imported oil rises slightly



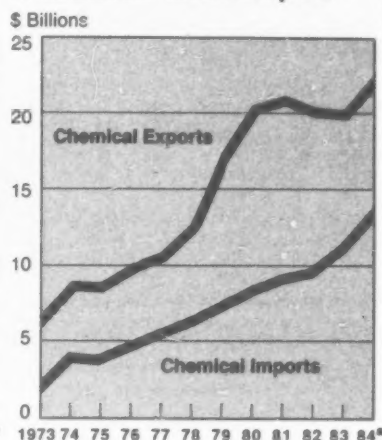
^a All petroleum products. ^b C&EN estimates.
Source: Bureau of the Census

Import surge lifts total U.S. trade deficit sharply ...



^a C&EN estimates. Source: Bureau of the Census

... and brings small decline in chemical trade surplus



fore, that U.S. exports this year will increase only about 8% to \$217 billion.

According to most economists, the dollar is more than strong—it is overvalued. In the past four years, the dollar has risen more than 60% against a basket of major foreign currencies. These include such traditionally strong currencies as the West German mark and the Japanese yen.

If the dollar is, in fact, the link between the international and domestic economic scenes, the linchpin on the domestic end is the huge deficit in the federal budget. Most economists agree that the deficit is a major reason that the U.S. dollar

now is so strong relative to major foreign currencies.

The federal deficit, when added to normal personal and business borrowing requirements, keeps interest rates higher than they otherwise would be. High interest rates, in turn, attract large amounts of foreign money into dollar assets. The result: an overvalued dollar.

That dollar's impact on the U.S. job market is substantial. C. Fred Bergsten, a former Treasury Department official and now director of the Institute for International Economics, estimates that more than 2 million jobs have been lost in industries that either export or compete with imports. U.S. multinational

Chemical exports rise modestly, but imports make dramatic gains

\$ Millions	U.S. chemical exports				U.S. chemical imports			
	1984 ^a	1983	1982	1981	1984 ^a	1983	1982	1981
Organic chemicals	\$ 6,311	\$ 5,326	\$ 5,440	\$ 5,929	\$ 4,352	\$ 3,477	\$2,960	\$2,974
Plastics and resins	4,014	3,732	3,650	3,809	1,523	1,098	766	780
Medicinals and pharmaceuticals	2,632	2,494	2,275	2,165	911	703	563	583
Inorganic chemicals	2,163	1,838	1,969	2,286	2,108	1,615	1,502	1,573
Fertilizers, manufactured	1,806	1,267	1,386	1,735	1,183	997	963	1,181
Radioactive materials	1,137	1,213	1,132	988	1,142	952	1,143	786
Pesticides and disinfectants	736	630	607	544	354	251	265	283
Flavors, perfumes, cosmetics, and toiletries	513	493	514	535	517	370	295	289
Pigments, paints, and varnishes	335	321	332	349	218	145	103	102
Cleaning and polishing materials	312	295	324	396	109	90	76	74
Explosives and pyrotechnics	178	87	90	90	95	64	67	61
Dyeing, coloring, and tanning materials	156	163	162	175	367	300	213	226
Miscellaneous	2,007	1,885	2,010	2,187	721	717	579	534
TOTAL	\$22,300	\$19,751	\$19,891	\$21,187	\$13,600	\$10,779	\$9,494	\$9,446

^a C&EN estimates. Source: Bureau of the Census

companies, he says, are shifting some of their production to foreign subsidiaries.

The obvious starting point for solving the growing U.S. dilemma in international trade is to reduce the federal deficit. Both the Administration and Congress will be spending a lot of time trying to do just that.

Cutting the federal deficit would force interest rates lower. Dollar assets would become less attractive to foreigners. The value of the dollar would decline.

Bergsten suggests that the value of the dollar should be corrected 30 to 35% from current levels. But how the U.S. handles the problem can have a huge impact, not only on the U.S. economy, but on the world economy and international trade as well.

Most economists agree that the dollar should not—indeed, cannot—stay at its present level. But if its value drops too far too fast, the economic consequences could be devastating. Interest rates would take off again. Double-digit inflation would return. And most of the world would find itself in another recession.

The consensus seems to be that the only workable solution is to reduce the budget deficit gradually. This, in turn, will lower interest rates and dollar-exchange rates gradually, and steer the U.S. economy to a "soft landing."

How these problems are resolved will have a tremendous impact on U.S. chemical trade. Chemical exports and imports are no less susceptible to the influences of a strong

dollar, a strong domestic economy, and weaker economies overseas than any other exports or imports.

The U.S. chemical industry has prided itself on its long string of chemical trade surpluses. In the early 1970s, the surplus alone was greater than the value of chemical imports.

Now, that chemical trade surplus is dwindling, and it has long since dipped below the value of chemical imports. This year, U.S. chemical companies will export \$22.3 billion worth of chemicals, up a respectable 13% over 1983. Chemical imports, however, have flooded the country to the tune of \$13.6 billion, a disconcerting 26% increase over last year.

As a result, the vaunted chemical trade surplus will shrink to \$8.7 billion, the fourth consecutive year in which it has declined. In 1980, it stood at a lofty \$12.1 billion. And where once the U.S. imported less than 40% as much chemicals as it exported, it now imports more than 60%.

Myron T. Foveaux, assistant director of government relations for the Manufacturing Chemists Association, estimates that chemical exports will increase only 3% next year. The Commerce Department, meanwhile, says that 1985's chemical imports will be only 4% higher.

If both these estimates are correct, the chemical trade surplus will improve slightly. But a lot depends on how much the U.S. economy slows. A slower economic pace would curb chemical imports.

But, if the U.S. economy is the locomotive that pulls the world

Chemical trade with West Europe shows an unusual deficit

\$ Millions	1984 ^a	1983
U.S. CHEMICAL EXPORTS		
Canada	\$ 2,810	\$ 2,546
Latin America	3,746	3,273
Western Europe	6,422	5,892
Eastern Europe	268	306
Japan	2,921	2,607
Communist Asia	602	353
Middle East	424	423
Rest of Asia	3,278	2,859
Australasia	937	696
Africa	535	492
Other	357	304
TOTAL	\$22,300	\$19,751

\$ Millions	1984 ^a	1983
U.S. CHEMICAL IMPORTS		
Canada	\$ 2,897	\$ 2,390
Latin America	1,210	924
Western Europe	6,460	5,020
Eastern Europe	313	197
Japan	1,319	1,099
Communist Asia	163	131
Middle East	123	113
Rest of Asia	381	283
Australasia	258	234
Africa	204	227
Other	272	161
TOTAL	\$13,600	\$10,779

a C&EN estimates. Source: Bureau of the Census

economy, a slowdown in the U.S. could nip recovery elsewhere. This would hurt U.S. chemical export prospects.

Next year, too, the impact of Saudi Arabia's petrochemical exports will begin to be felt. All of these factors will influence the trade fortunes of U.S. chemical companies.

And overshadowing all of them will be the value of the U.S. dollar. □

Lackluster agricultural exports and soaring imports lead to record U.S. trade deficit

\$ Billions	U.S. exports				U.S. imports			
	1984 ^a	1983	1982	1981	1984 ^a	1983	1982	1981
Chemicals	\$ 22.3	\$ 19.8	\$ 19.9	\$ 21.2	\$ 13.6	\$ 10.8	\$ 9.5	\$ 9.4
Machinery and transportation equipment	89.3	82.6	87.1	95.7	120.0	86.1	73.3	69.7
Other manufactured goods	30.8	30.0	33.0	37.3	89.8	66.5	61.1	63.4
Food and live animals	24.0	24.2	24.0	30.3	18.5	15.4	14.5	15.2
Beverages and tobacco	2.4	2.8	3.0	2.9	3.6	3.4	3.4	3.1
Minerals fuels, lubricants, and related materials	9.1	9.5	12.7	10.3	62.7	58.0	65.4	81.4
Crude materials (inedible) other than fuels	21.1	18.6	19.2	21.0	11.2	9.6	8.6	11.0
Animal and vegetable oils and fats	2.0	1.4	1.5	1.7	0.7	0.5	0.4	0.5
All other products	10.4	7.0	6.9	8.4	9.9	7.7	7.7	7.3
TOTAL	\$217.0^b	\$200.5^b	\$212.2^b	\$233.7^b	\$330.0	\$258.0	\$244.0	\$261.0

a C&EN estimates. b Includes re-exported imports (not included in individual product categories). Source: Bureau of the Census



WESTERN EUROPE

**Slow future growth
and more competitive
markets for many
bulk chemicals remain
a severe threat**

Dermot A. O'Sullivan, C&EN London

West European chemical companies are coming through this year with flying colors. Most executives are in accord with BASF chairman Hans Albers, who says, "Both in respect to quantity and quality, 1984 will be remembered in our annals as a good year."

The extent of the improvement in the first nine months this year, compared to last year's similar period, shows in the financial statements of those companies that issue quarterly results. Akzo, headquartered in Arnhem, the Netherlands, which for some time has been bogged down by the general weakness in man-made fibers, doubled its net profit in the January-to-September period from the year-earlier level.

Akzo's operating income from fibers gained 147% to \$65.1 million (22% of total operating income), followed closely by chemicals, up 141% to \$87.1 million (29% of the total). Coatings turned in the poorest operating income gain, 3% to \$33.1 million (11% of the total)—largely because of the adverse influence of strikes in the metalworking and automotive industries and poor results of operations in France.

Chemical makers are experiencing a year of sharply improved profits

Gains in the nine-month earnings of BASF, Bayer, Hoechst, Imperial Chemical Industries (ICI), and Norsk Hydro over 1983 were 60% or better. All the companies' results were more encouraging considering the comparatively moderate improvement in their sales.

For companies active in agrichemicals and pharmaceuticals, the profit surge, ironically, is a cause for some embarrassment. There is an upturn of criticism on the part of environmental activists over growing use of pesticides. And the public's increased awareness of profits generated by pharmaceutical sales has sparked a debate on the issue of prescribing generic drugs.

The chemical earnings of European-based oil companies, too, have rebounded. London-based BP

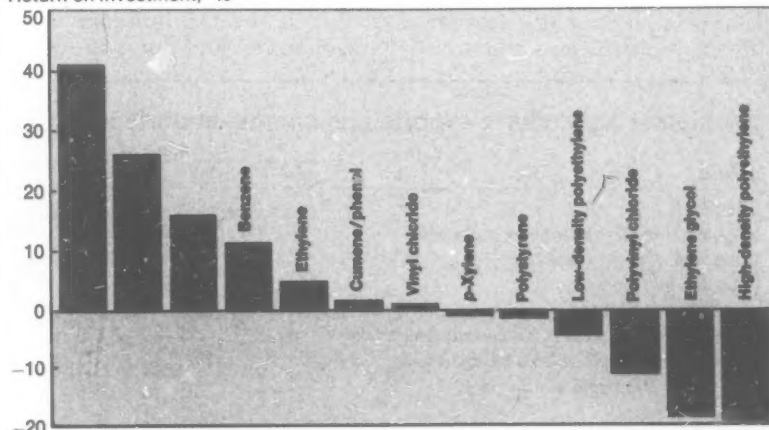
Chemicals International, for instance, achieved an operating profit of \$74.2 million in sharp contrast to the \$81.6 million loss experienced between January and September last year (calculated on a comparable currency exchange basis). Sales were up more than 15% to almost \$1.8 billion. Net income from the global chemical activities of Royal Dutch/Shell (including those in Canada and the U.S.) surged a remarkable 329% to nearly \$313 million on sales that advanced 17% to \$5.4 billion.

A number of factors have helped bolster the fortunes of European chemical companies this year. Predominant among them are the U.S. economic recovery and the continued strengthening of the U.S. dollar against European currencies.

The boom in U.S. demand has led

Some petrochemicals are still unprofitable in Europe

Return on investment, %



Based on third-quarter 1984 sales prices and investment costs for a new plant.
Source: Chem Systems International

to an increase in sales opportunities for Europeans, both as exporters and as operators themselves of U.S.-based production units. Bayer chairman Hermann-Josef Strenger, for example, notes that his company's U.S. sales during the first nine months of this year advanced 29% to \$2.6 billion, almost a quarter of the company's total worldwide sales. Coincidentally, U.S. chemical producers largely have focused their attention on meeting their own domestic demand. Their competitive threat in Europe and elsewhere has receded because there has been less incentive to export.

The seemingly inexorable hardening of the dollar against European currencies continued this year. In September, the value of the French franc, the Italian lira, and the U.K. pound, in dollar terms, was about 50% what it had been in January 1981. The West German mark's value has stood up somewhat better, declining about 33% against the dollar over the same period. In the shorter time span between September 1983 and September this year, the franc moved down 13%, the lira 14%, the pound 16%, and the mark 12%.

Although the relative weakness of European currencies has ruffled some political feathers out of a sense of national pride, it has done much to boost the price competitiveness of European chemicals in dollar trading areas. Moreover, dollar revenues are showing up as higher figures when translated into European currencies, thereby adding to the fiscal gains of companies headquartered in Frankfurt, London, Paris, and elsewhere in Europe.

Of course, the converse also holds for managers of U.S. companies operating throughout Europe. Even though their business may be attaining satisfactory sales and earnings gains at local currency levels, results in dollars don't look nearly so well when reviewed in the boardrooms of their U.S. corporate parents.

Hardening of the dollar doesn't always work to the Europeans' benefit, however. Oil and naphtha, for instance, priced in dollars, cost more to purchase in local currencies when the dollar is strong. However, prices of oil and gas have held fairly steady

this year because the general weakening of oil prices has tended to compensate for the parity shifts.

Also, adds David R. Clair, president of Essochem Europe, "higher West European utilization of plant capacity seems to have more than offset the negative impact of exchange rates on European feedstock and energy costs."

One area where U.S. companies in Europe have gained from the dollar's strength is in labor costs. The experience at Du Pont, for example, is that "the 1984 European payroll, although it has increased in terms of local currency, when expressed in dollars will amount to no more than 85 to 90% of the corresponding 1983 figure because of the continuing strengthening of the U.S. currency."

Overall, wages in the European chemical industry this year moved up 3 to 7%, generally at or slightly below inflation. There are some ex-

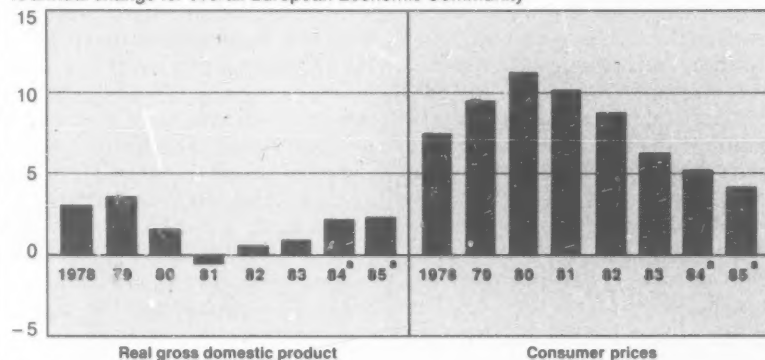
ceptions, however. For Akzo and DSM in the Netherlands, the level was unchanged from 1983. Because of the high rate of Dutch unemployment, about 15% of the labor force, "the unions were very cautious in their demands," one Akzo executive notes. On the other end of the spectrum, there was a 14% increase in salaries in Italy, well ahead of the 10% rate of inflation there.

The surge in profits notwithstanding, chemical company managers admit to some apprehension about the near-term outlook. The consensus is that business expansion will continue next year, but at a slower rate. It also appears likely, moreover, that the U.S. economy will not grow at a rate comparable to the rate in 1984, with the result that U.S. producers once again may sharpen their export drive. A weakening of the dollar, should it occur, would exacerbate the situation.

Anil C. Parikh, director of plan-

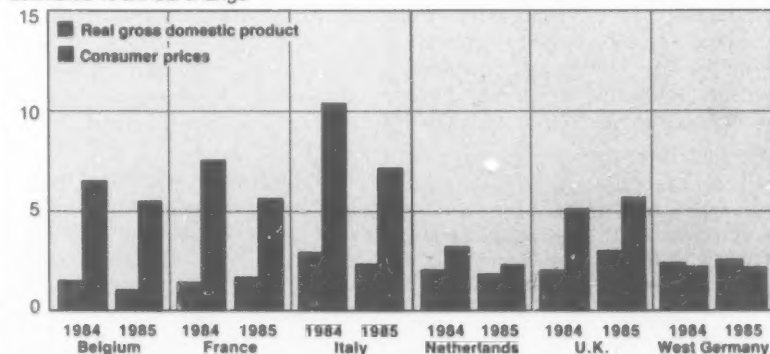
Economies grow moderately but inflation slows sharply . . .

% annual change for overall European Economic Community



. . . in the major nations of Western Europe

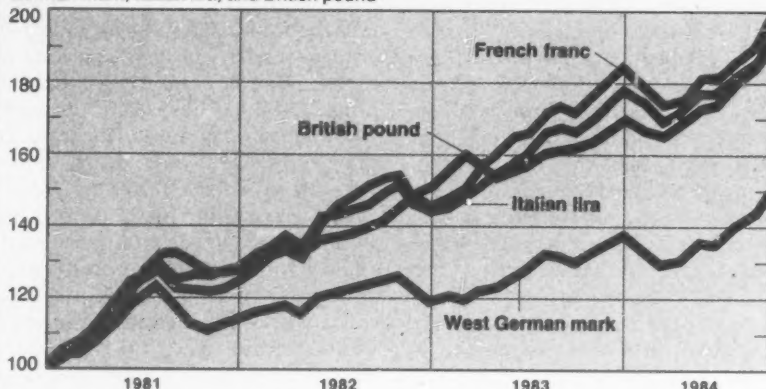
Estimated % annual change



^a Estimated. Source: Commission of the European Communities

Dollar is stronger than ever in Europe this year

Relative value of U.S. dollar vs. French franc, West German mark, Italian lira, and British pound^a



Note: During January 1981, the average value of the dollar stood at 4.64 francs, 2.01 marks, 953 lira, 0.4 pound.
^a January 1982 = 100. Source: International Monetary Fund

ning and business development at Monsanto Europe's Brussels headquarters, takes a somewhat more sanguine view. "There already are signs that Western Europe is not as dependent on the U.S. economy as it was in the past," he maintains.

Citing prognostications that the rate of gross domestic product (GDP) growth in the U.S. next year might be only about half this year's level and that it might retreat further in 1986, he doesn't foresee any such drop in the European economies. Indeed, he expects Europe's GDP growth in 1986 to just about match that of the U.S. "This should result in a more stable situation as far as the European chemical industry is concerned," he remarks.

A link always has existed between growth in GDP and that of the chemical industry. In the heady expansionist times of the 1960s and early 1970s, it was almost an immutable fact that a GDP multiplier of 2 or 2.5 could be used to gauge growth of commodity chemicals. In other words, if GDP grew 4%, demand for chemicals could be relied on to ex-

pand 8 or 10%. Currently, however, this multiplier has moved down to close to 1.

Gaston Beauregard, head of planning at Shell International Chemical's petrochemicals division in London, believes there is "need to look at our industry in relation to the index of industrial production rather than the more conventional GDP." He argues that this would provide a more accurate picture of the link between chemicals and the overall level of industrial activity "because a greater proportion of GDP now is generated by service industries."

Monsanto's Parikh agrees. "The index of industrial production undergoes bigger swings than GDP does. The peaks are higher, the troughs are lower. But either way, the relationship between industrial production and chemical production is valid."

Ray R. Knowland, BP Chemicals' managing director, admits to concern that 1986 will see a downturn in business generally. But some worry that this view could become a self-fulfilling prophecy if expressed often enough.

Although acknowledging that the situation is serious, Hugo Lever, director general of the European Council of Chemical Manufacturers' Fédérations (CEFIC), contends that economic cycles are to some extent "a psychological thing, a state of mind. We can talk ourselves into trouble," he remarks, although he admits that

the "current deficits that are preventing many governments from taking appropriate corrective actions can be a real problem."

It is true, nonetheless, that global business does move in cycles, and a decline may be on the way. Indeed, there are indications that a downturn already has set in for European man-made fibers. Although output of acrylics, polyamides, and polyesters has risen slightly from 1983 levels, deliveries to customers have retreated. The drop is greatest for acrylics, off almost 3% to about 1.66 billion lb. Deliveries of the polyesters are off 1.5% to 1.57 billion lb and deliveries of polyamides are down 1.1% to about 1.16 billion lb.

Experts at the International Rayon & Synthetic Fibers Committee (CIRFS) in Paris, who monitor the industry, foresee the pattern continuing next year. They also are concerned about the arrival in Western Europe of acrylic fibers from large plants that have come on stream recently in Turkey. Turkish acrylics entering Europe this year amounted to about 26 million lb, up from none previously.

Although the man-made fibers operations of European chemical companies hardly can be considered robust, business has been creeping slowly into the black in the past year or so. Some measure of help has come from the multifiber arrangement (MFA) drawn up by the General Agreement on Tariffs & Trade (GATT) to ensure orderly expansion in world trade in textiles. MFA imposes a ceiling on textile imports from developing countries.

The current MFA, which regulates 80% of world trade in textiles, expires July 31, 1986. Presumably, moves will get under way next year toward its renewal. But already the European Bureau of Consumers' Unions in Brussels is scoring MFA as having "failed in all its objectives except that of operating as a highly protectionist device for European industry," claiming that it has resulted in price increases of up to 30% on textiles and clothing imported into Europe.

In the petrochemicals arena, the imminent arrival of products from Saudi Arabia is the main topic of discussion. Two large methanol units now are on stream there. Soon, units

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making ethylene glycol, linear low-density polyethylene, and other petrochemicals will start up.

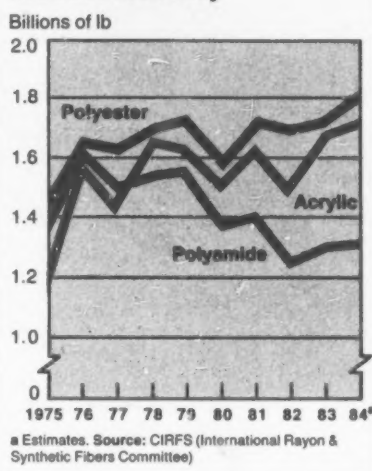
Reactions of Europeans to what undoubtedly will be a new competitive dimension in the marketplace are varied. John N. Turnbull, business general manager for polyolefins at BP Chemicals, makes the point that "the issue of Saudi petrochemicals is not news any more. We have been aware of their coming and have been making the necessary adjustments." Adds CEFIC's Lever, "A lot of the emotion has been taken out of the Middle East chemicals threat. The fact that people there can make petrochemicals from gas that's now flared is reasonable."

Nonetheless, there have been understandable noises of concern, particularly by those whose market shares will come under threat from Saudi products. Some have suggested invoking import protective measures under European Economic Community or GATT rules. Others have talked about cutting prices to maintain market share.

At the Society of Chemical Industry meeting in Cannes, France, in October, Günter Metz, a board member of Hoechst, made the point that "protectionist measures lead to a decline in international trade, which is harmful to all concerned. Restraints are regarded by the German chemical industry, and hopefully by the West European chemical industry as a whole, as unsuited for solving the problem of future petrochemical imports from the Middle East."

Metz expresses the hope that "the partners of the Saudis in chemical joint ventures will exercise responsibility when introducing onto in-

Fiber output makes modest recovery



dividual markets the quantities which they want to sell in Europe." But he admits that "a more difficult problem will be the quantities entering the European markets through dealers or direct from the oil-producing countries."

Acknowledging that import controls would achieve nothing, Martin Trowbridge, director general of the U.K.'s Chemical Industries Association, concedes that "Middle East countries will represent very tough competition for us. We reckon that by 1990, they will have taken something like a million tons a year of business from the West European chemical industry."

Trowbridge points out that this volume about matches the expected growth in the market by 1990. "This means that we shall all continue to fight for a no-growth market. There will be very difficult trading conditions, and prices will come under

severe attack." As the year progressed, European producers have been able to push through price increases on most of their bulk products as customers replenished stocks. This, coupled with better plant capacity utilization, contributed to their higher profits. In recent weeks, however, prices have been drifting down again, particularly for commodity plastics. The weakness, according to Shell's Beauregard, reflects some inventory reduction. But he thinks that part of the downturn might be in anticipation of the impact of supplies from the Middle East, which actually won't materialize until well into next year.

When it comes to competing against the Saudi Arabians on prices, "There is no way the European producers can win," Mike Hyde, publisher of *Chemical Insight* and a respected observer of the international petrochemicals scene, told a recent meeting of the European Petrochemical Association. "Saudi Basic Industries Corp. and its joint venture partners will match any price cuts. They will do so in order to load their new plants. They are in a much better position to ride out any price storms."

The overhanging Middle East competition comes at a time when European petrochemicals already are encountering troubles. According to David S. Glass at Chem Systems' London office, who compiles a quarterly review of the field, profit margins over operating and selling costs for a number of key chemicals are narrowing close to the break-even line. For several chemicals, return on new capital investment already is negative.

Polypropylene, with good growth

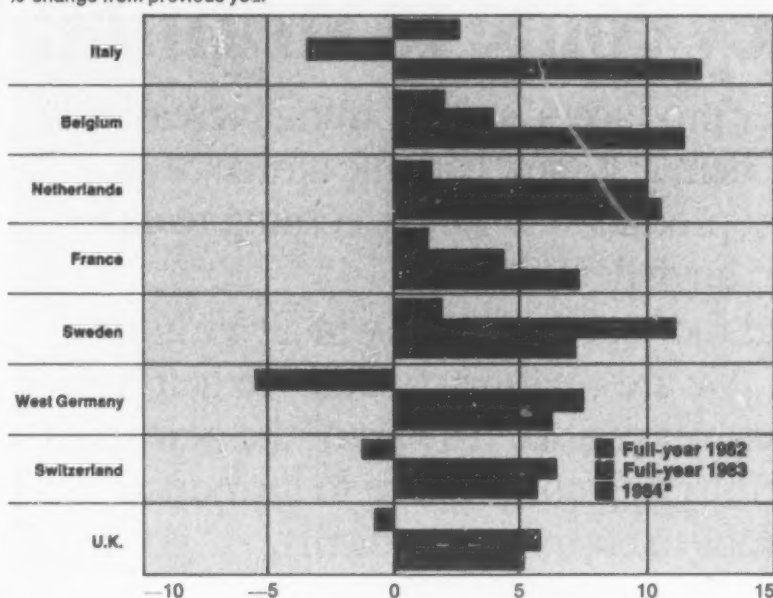
Slow growth seen for thermoplastics in West Europe during 1980s

Consumption, millions of lb	1980	1981	1982	1983	1984 ^a	1985 ^a	1990 ^a	Estimated annual change 1980-90
Linear low-density polyethylene	132	198	297	484	770	1,100	2,200	32%
Polypropylene	2,805	3,036	3,124	3,608	3,960	4,180	4,840	6
Acrylonitrile-butadiene-styrene	684	669	715	803	858	902	990	4
High-density polyethylene	3,133	3,047	3,076	3,476	3,520	3,564	3,960	2
Polystyrene	3,615	3,410	3,403	3,740	3,850	3,850	4,103	1
Polyvinyl chloride	8,195	7,568	7,700	8,426	8,492	8,580	9,020	1
Low-density polyethylene	8,323	7,623	7,832	8,316	8,360	7,546	7,040	-2
TOTAL	26,887	25,551	26,147	28,853	29,810	29,722	32,153	2%

^a Estimates. Source: Chem Systems International

Chemical production rises for second year

% change from previous year



* 1984 data are for first nine months for Sweden, Switzerland, U.K., and West Germany, first eight months for France and Italy, first seven months for the Netherlands, and first six months for Belgium.

Sources: National chemical federations for each country

prospects still ahead, continues sound. So does acrylonitrile, largely because of strong demand for acrylonitrile-butadiene-styrene polymer. But low-density polyethylene and polyvinyl chloride, which were performing handsomely early this year, are doing much more poorly now. And returns on high-density polyethylene have been poor all along.

Ethylene glycol is in equally bad shape. Western Europe has switched from being a net exporter to becoming a net importer. According to George Ewart, ICI's chemical products general manager, some 1.28 billion lb a year of existing European glycol capacity, 45% of the total, will need to be phased out by 1990 in face of anticipated annual imports of 660 million lb, the bulk of that originating in the Middle East. For this reason, ICI and others are scaling down their involvement in unprofitable glycol, concentrating instead on higher-valued specialty derivatives of ethylene oxide.

Ray Knowland of BP Chemicals, referring to the strong profit surge for European chemical companies this year, comments that "profits are

an excellent anesthetic to dull our senses to inherent problems." Probably foremost among the inherent problems, as far as the European chemical industry is concerned, is the multiplicity of producers.

In this connection, Knowland cites the fact that 19 makers of low-density polyethylene in Western Europe share a total annual capacity of 11.9 billion lb. This means that, on average, each producer has a capacity of only about 625 million lb. In contrast, the 11 producers in the U.S., where total capacity is 9.7 billion lb, each has an average yearly output capability of 880 million lb, Knowland notes.

In fairness, there have been moves to restructure the chemical industry throughout Europe. Most dramatic were measures taken in France and Italy over the past few years, where large segments of production and sales were divided among fewer companies.

This year, West Germany's Hoechst decided to bow out of LDPE and ethylene-vinyl acetate copolymer. Hoechst's Ruhrchemie subsidiary is leasing its production units on a long-term basis to Italy's EniChem,

which also takes over Hoechst's marketing network for the products.

Spain also has restructured its LDPE business. Recently, Dow and the state-owned Empresa Nacional del Petróleo (Enpetrol) jointly took over a unit in Tarragona from Union Explosivos Rio Tinto. Dow and Enpetrol have their own LDPE plants in Spain and will continue to compete in the marketplace. But the move reduces the number of Spanish producers from three to two. Observers believe it could signal a step toward eventual reduction in overall annual capacity from the present 1 billion lb or so, which is much more than Spain's domestic demand.

Atochem of France and ICI have opened discussions centering on ethylene oxide derivatives, ethylene-vinyl acetate copolymer, and LDPE. The goal is for ICI to phase out production of the copolymer and LDPE at Rozenburg, the Netherlands, and transfer its marketing network for the products to Atochem, which produces them in France. In return, ICI would acquire Atochem's French plant making specialty ethylene oxide derivatives, thereby extending the range of its own ethylene oxide and glycol operations in the U.K.

"Restructuring of the European monomers and commodity plastics industry has gone too slowly, however," says Simon de Bree, executive vice president for plastics at DSM of the Netherlands. Noting that his company has a strong position in the field, he states that "DSM is prepared to discuss cooperation with other producers and combine forces with them to contribute to the restructuring of the industry."

Ethylene overcapacity remains one of Western Europe's biggest problem areas. Despite plant closures in the past few years that cut annual output capability about 11% from almost 38 billion lb, the current 34 billion lb-per-year total is still well above this year's demand of some 26 billion lb. And 1984 is a good year. With a dip expected, it could be several years before production from European crackers moves back up to this year's level, Shell's Beauregard surmises.

One of the problems is that of the nearly 40 ethylene producers in Eu-

rope, more than half now rely on a single cracker. As Beauregard points out, closure of a producer's sole unit is the hardest step to take. Another problem is that national governments have a major stake in 13 of the companies that make the olefin throughout Europe.

Unless something drastic is done, the position will worsen next year with the startup of a 1.1 billion lb-per-year ethylene plant at Moss-morran, Scotland. Funded jointly by Esso and Shell, feedstock will be ethane extracted from the partners' North Sea oil fields.

The Mossmorran cracker will be the only one in Europe based on ethane. According to Esso and Shell, who individually operate crackers elsewhere in Europe, it will have important production economies compared to units that use liquid feedstocks, such as naphtha.

ICI, meanwhile, is waiting judgment on its legal action contesting tax concessions on the North Sea-derived ethane that the U.K. government granted to Esso and Shell. The tax break, ICI claims, will result in an unfair competitive edge that, it goes on to warn, could have serious consequences for its own ethylene-based petrochemical production at Wilton, England.

With the prospect of continuing competitive pressures on bulk chemicals, Europeans are stepping up their efforts to improve process efficiencies and cut energy use. They also are reducing their dependence on commodities by shifting to more profitable specialty areas.

Matt Steinbrüchel, director of planning at Dow Europe, for example, expects business to be split about 60/40 between specialties and commodities in three or four years, largely because of selective acquisitions and an ongoing diversification program. This will reverse Dow Europe's portfolio profile of a few years ago.

ICI chairman John Harvey-Jones observes that last year, bulk chemicals accounted for 55% of the company's sales but just 16% of profits. "In 1979, 60% of our sales and 40% of our profits were derived from cyclical businesses. We are moving more toward specialties and 'effect' chemicals while sustaining the best

Slow economic growth keeps unemployment high

Business recovery throughout the European Economic Community became evident in last year's closing months and gained momentum as this year progressed. Gross domestic product (GDP) this year for the community is expected to advance about 2.2% from the 1983 level. A like gain is expected next year.

Though the GDP gain remains below 1979's 3.4% increase, the current upswing is a welcome change from 1982 and 1983 when the advance in each year was less than 1%. However, as the 1984 annual economic review of the Commission of the European Communities points out, "Growth rates (for this year and next) are too modest to result in a reduction of unemployment. The medium-term outlook for output and employment remains totally unsatisfactory."

Unemployment, a major problem for

the 10 EEC member nations, has been rising during the past 20 years, and no end appears in sight. This year unemployment stands at about 11% of the workforce, up from last year's 10.6%. In 1985, it is expected to advance to 11.5%.

Unemployment rates vary. Belgium, Denmark, France, Ireland, Italy, the Netherlands, and the U.K. are highest, with double-digit rates, led by Ireland with 16.5%. West Germany and Greece have a comparatively moderate 8.5%, but the lowest level is in Luxembourg, with 1.7%.

The commission's review notes that much of present unemployment in the community may be attributed to the high labor costs and labor market rigidities. Examples cited of such rigidities are nonwage costs, minimum wage levels, rules governing recruitment and dismissal, and pension schemes.

of our commodity businesses. You cannot make ICI totally recession-proof," he adds. "But we know where we are going, and, what is more, we are getting there."

Anil Parikh of Monsanto notes, "We began moving out of commodity plastics and fibers in Europe before most other companies. Between 1978 and 1983, there was only one year when we didn't divest something. Now we are focusing on growth. We are running a tighter ship with smaller sales, but we have a healthier bottom line."

Growth is foreseen for specialty plastics, elastomers, and the like. Typical of some high-priced specialties are the fluorinated chemicals and polymers of Du Pont and ICI and the cross-linked polyethylene and thermoplastic elastomers of Dow. At DSM, development is under way on a novel nylon 46 that promises to pose a challenge to nylon 6 and 66, as well as on superstrong polyethylene fiber for use in plastic composites.

Du Pont, ICI, and others in Europe, too, are bolstering their position in electronic chemicals and related fields. Du Pont, for instance, invested more than \$30 million this year in Europe in a drive to bolster its posi-

tion as a supplier of electronic materials and systems, and expects to continue to spend at a similar rate during the next year or so. Products made at its plants in France, West Germany, the Netherlands, and the U.K. include electrical connectors, thick film pastes, and dry film resists.

Noting such moves, Charles Doscher, president of Eni Chemical, the international arm of EniChem, cautions that chemical companies that try to move into specialties to meet the threat from low-cost Middle Eastern imports must guard against putting their established commodity businesses at risk. "European industry should not neglect its commodity plastics and chemical products or be guilty of neglecting its customers who depend on these products," he points out.

Doscher urges European producers "to recognize that bulk products still are the core of today's business. A big effort has to be made to ensure viability in commodities as well as specialties." This effort, he notes, will involve a further round of restructuring, production efficiency programs, and continuing investment to ensure a sustained flow of new types or grades of products. □



JAPAN

Chemical firms strive to overcome high costs and inefficiencies to maintain markets against foreign competitors

Earl V. Anderson, C&EN New York

Japanese chemical companies had been so low for so long that there was almost no other way to go but up. They certainly expected 1984 to be better than the past few years.

So far, based on their performance three quarters of the way through fiscal 1984 (which ends March 1985), they haven't been disappointed. In

Chemical business recovers, but good times may not last long

fact, most Japanese chemical companies are pleasantly surprised, because fiscal 1984 is turning out to be even better than expected.

For most important chemicals and plastics, production is up—in some cases significantly. Selling prices have firmed. Prices of raw materials, especially naphtha for the petrochemical industry, have eased.

This happy combination is reflected in company earnings statements. One good indicator is the performance of the 10 top Japanese chemical companies. Their combined sales are likely to be up about 5 to 6% in this fiscal year. But their net income will surge about 60%.

As a result, the combined profit margin (net income as a per cent of sales) of the 10 firms will improve to 1.5%. That may not sound like very

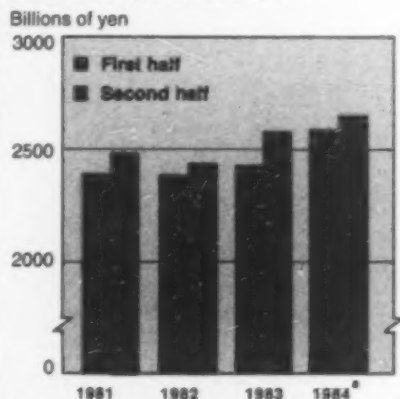
much to, say, most U.S. chemical companies. But compared to the anemic 0.8% profit margin that the 10 companies reported, on average, during the previous four fiscal years, it seems lofty to them.

The euphoria may not last, however. Already there are signs that, in some product lines, chemical firms may have overproduced. Inventories are building ominously.

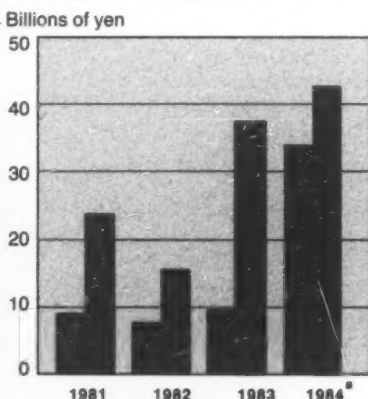
Ethylene and its derivatives are a good example. Despite a conscious effort to curb ethylene output and to scrap excess capacity, production took off this year. In calendar 1984, ethylene output probably will hit 4.1 million to 4.2 million metric tons, 12 to 14% higher than last year. This will be the first time that ethylene production has topped 4 million metric tons in Japan since 1980.

Business is better this year for Japanese chemical producers

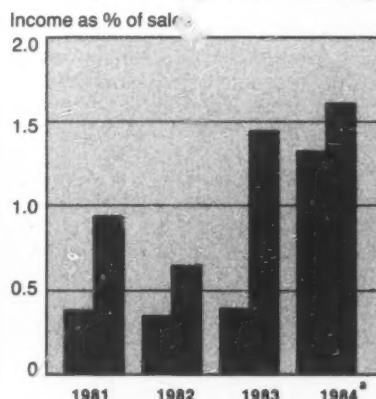
With sales up moderately . . .



earnings have snapped back . . .



. . . and profit margins are widening



* Estimated. Note: Data for fiscal years ending March 31. Based on results of 10 leading Japanese petrochemical companies: Mitsubishi Chemical Industries, Sumitomo Chemical, Asahi Chemical Industry, Toray Industries, Mitsui Toatsu Chemicals, Teijin, Showa Denko, Mitsubishi Petrochemical, Dainippon Ink & Chemicals, and Sekisui Chemical. Source: Toyo Keizai Shinposha

Yasunobu Kishimoto, president of Showa Denko and chairman of the Japan Petrochemical Industry Association, concedes that ethylene output, especially late in the year, may be too high. He notes, too, that inventories of polyethylene and other major general-purpose resins have been increasing all along the chain from producer to final consumer.

There also is a good deal of concern about Japan's economy. That may seem ludicrous, since Japan's gross national product now is expected to increase 5.3% (after adjustment for inflation) in fiscal 1984, well above early estimates of 4.1%.

But the concern is genuine. Much of Japan's economic recovery has been led by export expansion. In the April-June period, the nation's Economic Planning Agency estimates that 44% of Japan's economic growth came from exports. Even the increase in capital investment at home was sustained by export-oriented industries. Japanese economists worry because personal consumption, the biggest component of domestic private demand, still appears dull.

For Japan's chemical industry, both exports and domestic demand have increased. Still, there are reasons to doubt that it can look for lasting success in either sector.

Japanese chemical exports are likely to increase 12% this year to a record \$7.8 billion. A good share of the industry's export success must be credited to the U.S. economy. With domestic demand strong, U.S. companies have eased up on their efforts to grab a larger share of the southeast Asian market, which figures strongly in Japanese chemical export plans. Of course, a strong U.S. dollar also makes it easier for Japanese companies to compete against the U.S.

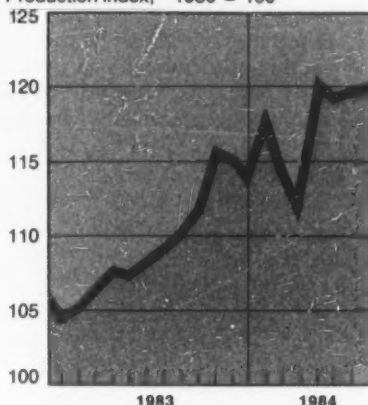
However, even a record \$7.8 billion in exports won't prevent the Japanese chemical trade deficit from increasing. Chemical imports probably will be up almost 17% to \$8.4 billion, boosting last year's chemical trade deficit of \$224 million up to about \$600 million.

In a sense, exports even benefit Japanese chemical companies in their own domestic market. Much of their domestic demand comes from export-oriented industries such as auto and home appliances.

Chemical output this year is up from a year ago

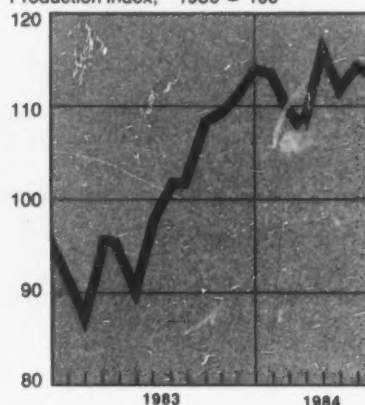
All chemicals

Production index, ^a 1980 = 100



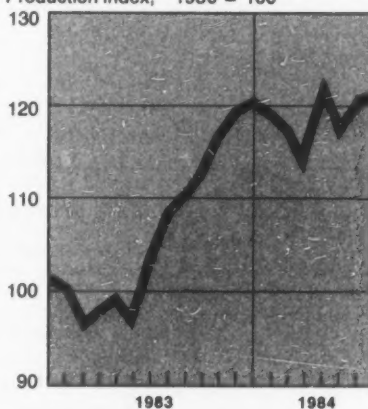
Petrochemicals

Production index, ^a 1980 = 100



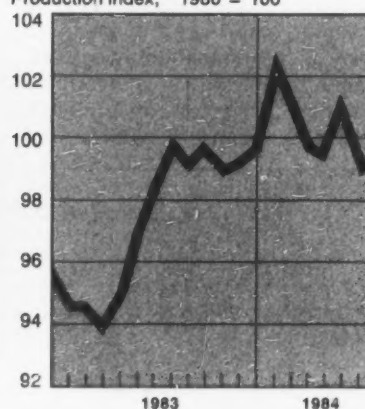
Plastics

Production index, ^a 1980 = 100



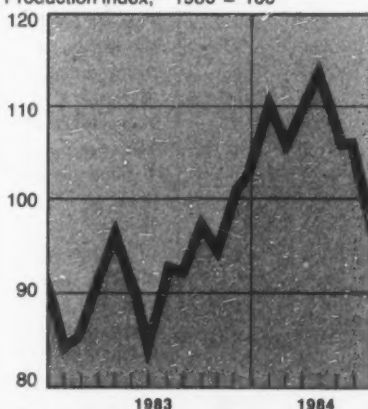
Synthetic fibers

Production index, ^a 1980 = 100



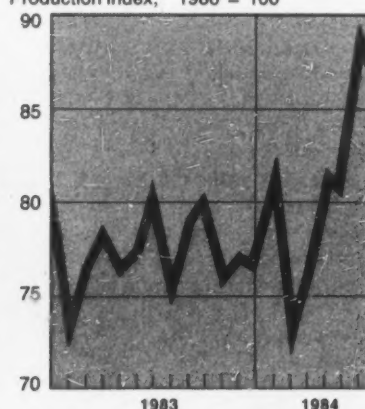
Synthetic rubber

Production index, ^a 1980 = 100



Fertilizers

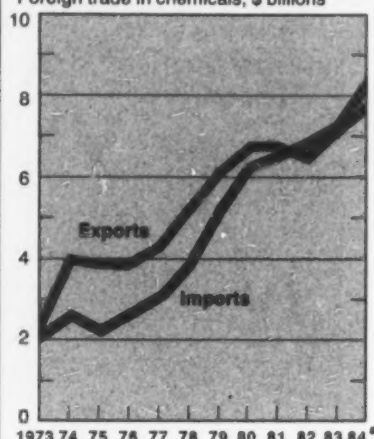
Production index, ^a 1980 = 100



^a Seasonally adjusted. Source: Ministry of International Trade & Industry

Sharp rise in imports boosts chemical trade deficit

Foreign trade in chemicals, \$ billions



a C&EN estimates.

Source: Ministry of International Trade & Industry

The chemical companies may soon find both their own exports and those of their major domestic customers vulnerable. The country's economic leaders are concerned that growth has been too export-depen-

dent and may take steps to change the situation. And Japan's political leaders are concerned about the country's embarrassingly high trade surplus and increasing complaints from major trading partners.

Meanwhile, chemical companies, particularly those heavily involved in petrochemicals, soon will be facing intense competition from new producers, such as Saudi Arabia, and from increased capacity in Canada. The impact will be felt in the all-important export markets of southeast Asia and at home as well.

If U.S. economic growth tapers off, as expected, Japan's chemical industry also can expect renewed competition from U.S. chemical exports. This will be especially true if the dollar weakens. Additional pressure from producers in Singapore and Taiwan will become apparent, too.

Meanwhile, a basic structural weakness of the petrochemical industry may spell trouble over the long haul.

Naphtha is still the primary petrochemical raw material, even though several companies are

weaning themselves away from it in favor of liquefied natural gas. In addition, the industry is reducing its dependence on domestic naphtha in favor of less-expensive imported naphtha. But these moves won't make Japanese petrochemical producers competitive with natural gas-based producers.

In addition, the industry is populated with companies that often are small compared to most of their international counterparts. Many of them have small, old plants.

All of this adds up to inefficiency and no one recognizes this better than the industry's leaders. With the Ministry of International Trade & Industry's help, and under the protective umbrella of a structural reform law, many segments of the industry are trying to restructure themselves. And many companies are realigning themselves into a few producer and sales groups.

These moves will help. But can they help enough? Says Kishimoto succinctly, "We can no longer remain optimistic about the future of the petrochemical industry." □

Economic recovery spurs petrochemical and plastics production

Thousands of metric tons unless otherwise indicated

	1983	Eight months 1984	1983	% change
INORGANIC CHEMICALS				
Ammonium chloride	435	268	296	-9%
Ammonium sulfate	1722	1221	1136	7
Calcium carbide	476	330	319	3
Calcium superphosphate	559	363	371	-2
Carbon black	568	401	366	10
Chlorine, liquid	818	587	533	10
Hydrochloric acid	511	332	336	-1
Nitrogen ^a	5369	3386	3489	11
Oxygen ^a	6434	4736	4193	13
Sodium carbonate	1103	695	758	-8
Sodium hydroxide	2863	2019	1854	9
Sodium silicate	588	386	385	0
Sulfuric acid	6662	4270	4421	-3
Titanium dioxide	196	131	130	1
ORGANIC CHEMICALS				
Acetaldehyde	255	191	161	19
Acetic acid	328	224	204	10
Acetone	247	162	164	-1
Acrylonitrile	459	340	286	19
Benzene ^b	1750	1316	1111	18
Butadiene	556	411	355	16
Butanol	229	158	144	10
Caprolactam	395	268	262	10
Cyclohexane	454	332	310	7

Thousands of metric tons unless otherwise indicated

	1983	Eight months 1984	1983	% change
DIESTERS				
Diethyl phthalate	231	169	148	14
Ethylene	3688	2900	2286	27
Ethylene dichloride	1736	1290	1098	17
Ethylene glycol	357	274	221	24
Ethylene oxide	468	345	295	17
Methanol	373	181	267	-32
Octanol	219	159	134	19
Phenol	271	182	177	3
Phthalic anhydride ^b	161	106	109	-3
Propylene	2658	1918	1688	14
Propylene glycol	194	133	123	8
Styrene	1184	913	713	28
Terephthalic acid	702	486	473	3
Toluene	831	514	553	-7
Toluene diisocyanate	74	49	47	4
Urea	980	658	672	-2
Xylene	1264	919	864	6
PLASTICS				
Phenolic resins	303	217	194	12
Polyethylene	1773	1514	1084	40
Polypropylene	1062	816	685	19
Polystyrene	1311	979	818	20
Polyvinyl chloride	1420	993	898	11
SYNTHETIC RUBBER				
	1002	782	656	19

a Millions of cubic meters. b Petroleum-based product only. Source: Ministry of International Trade & Industry



**Exports have bolstered
chemical output, but
the industry remains
concerned about high
costs for feedstocks**

Earl V. Anderson, C&EN New York

Rebound in chemicals may be grinding to an early halt

The welcome recovery that the Canadian chemical industry had been experiencing early this year may be running out of steam. Just as it appeared as if earnings were climbing back toward the heady levels of 1979, 1980, and early 1981, along came this year's third quarter, with generally lower sales and significantly lower earnings.

When they are finally compiled,

this year's fourth-quarter results probably won't be anything to brag about either. And with ominous signs that the Canadian economy is slowing down, it may well be that the rebound will end before the industry really is fully recovered.

Admittedly, there is a lot of uncertainty about Canada's economic outlook next year. Opinions of respected economists range from no recession to deep recession. Much depends upon what happens in the U.S., particularly to interest rates.

But a likely scenario is that the Canadian economy next year will be flirting dangerously close to a recession, if it isn't already. Real growth in gross national product, if there is any, will be minimal—about 1 to 1.5%—compared to this year's 3.5 to 4%.

Even now, much of Canada's economic momentum is coming from

exports to the U.S. This is especially true of chemicals. Canadian chemical exports will increase a tidy 23% this year to \$5.35 billion (Canadian). A disproportionate 66% of those exports will go to the U.S.

The increase in exports has helped Canada slip back into a positive chemical trade balance this year of about \$50 million, because imports are expected to rise 21% to \$5.3 billion. That's a far cry from the \$790 million surplus that the chemical industry racked up in 1981, but it is a lot more palatable than last year's deficit of nearly \$50 million.

Chemical exports are a key reason why Canadian chemical firms have been able to increase production of many key chemicals this year. At the same time, several plants, geared primarily to the export market, have come on stream in Alberta.

Alberta Gas Ethylene launched its second world-scale ethylene plant at Joffre—a 680,000 metric-ton-per-year behemoth. Shell Canada opened its \$1.4 billion synthetic crude oil refinery at Scotford. Included are a 300,000-metric-ton styrene plant and a 235,000-metric-ton benzene unit.

Meanwhile, Novacor has chipped in with a 270,000-metric-ton low-density polyethylene plant at Joffre. And Union Carbide Canada put on stream its huge 225,000-metric-ton ethylene glycol unit at Prentiss.

Not surprisingly, Canadian ethylene output has spurted this year to about 1.5 million metric tons, 22% higher than last year. Polyethylene (both low and high density) production will be up 16% to 720,000 metric tons.

Fertilizer has been another strong segment of the Canadian chemical industry. Production of ammonia

Output is up markedly this year for most chemicals

Thousands of metric tons	1984*	1983	1982	1981	1980	1979
Ammonia	3600	2888	2509	2654	2555	2405
Ammonium nitrate	990	934	1018	1212	873	914
Ammonium phosphate	1400	1259	888	1355	1466	1336
Benzene	580	580	504	571	604	492
Chlorine	1420	1385	1233	1292	1303	1031
Ethylene	1460	1196	1013	1330	1184	1014
Hydrochloric acid, 100%	165	170	135	188	177	154
Phosphoric acid, 100% P ₂ O ₅	720	656	503	744	808	748
Polyethylene	720	623	571	633	641	628
Polyvinyl chloride	245	243	194	222	190	145
Propylene	680	715	618	671	590	na
Sodium chlorate	300	294	264	255	245	224
Sodium hydroxide	1470	1528	1367	1458	1459	1138
Sulfuric acid	4100	3686	3131	4117	4295	3666
Urea	2150	1445	1231	1303	1274	2121

* C&EN estimates. na = not available. Source: Statistics Canada

will increase 25% to 3.6 million metric tons this year. And urea output will be up a whopping 49% to 2.15 million metric tons.

These larger volumes, along with higher selling prices in some cases, helped Canadian chemical companies improve their sales and profit picture—at least through the first six months of the year. But in the third quarter, disturbing signs started to creep into earnings statements.

For Celanese Canada, third-quarter sales were \$89.2 million, slightly lower than in last year's third quarter. More critical, though, the company lost \$241,000 on those sales, its first quarterly loss in two years.

Celanese expected the usual seasonal decline in sales during the third quarter. But it says the decline was sharper than normal. In part, this was due to increased textile and apparel imports. The company anticipates a return to profitability during the fourth quarter.

Not all companies are optimistic about the fourth quarter, however. Du Pont Canada, for instance, had net earnings of \$36.1 million for the first nine months, compared to \$22.7 million last year. But company president J. Edward Newall says that fourth-quarter sales and earnings will be below "the excellent results achieved in 1983." The reason: continued weakness in fibers and more intense competition in many chemicals and plastics markets.

Union Carbide Canada, which lost \$903,000 on sales of \$176 million in the third quarter, attributes its lingering troubles to the petrochemical cost-price squeeze. The chief culprits, according to company chairman W. Norman Kissick, are noncompetitive Canadian petrochemical feedstock costs and increasingly depressed prices for petrochemical products, particularly for polyethylene.

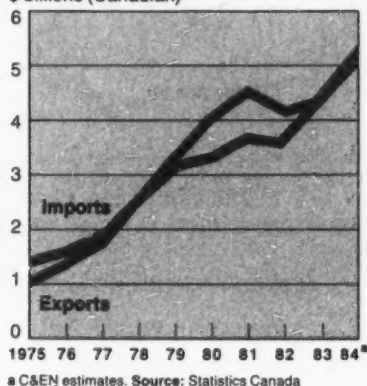
Thus, the Canadian chemical industry seems to be on the verge of facing a new set of problems even before its old ones have been completely solved. There is no doubt that the industry has been badly wounded by Canada's National Energy Program. For some time, chemical leaders have been urging the government to ease the tax burdens that make its feedstock more expensive than that of other producers, particularly those on the U.S. Gulf Coast. But, despite some encouraging promises from the new Conservative federal government, salvation is far from guaranteed.

Now, Canadian chemical companies also must face the prospects of another economic slowdown before they have recovered fully from the last one. The U.S. economy already is slowing down and prospects for next year aren't very encouraging.

Those all-important Canadian chemical exports to the U.S. could feel the pinch. And if the world economy follows that of the U.S. into

Chemical trade balance regains a slim surplus

Foreign trade in chemicals, \$ billions (Canadian)

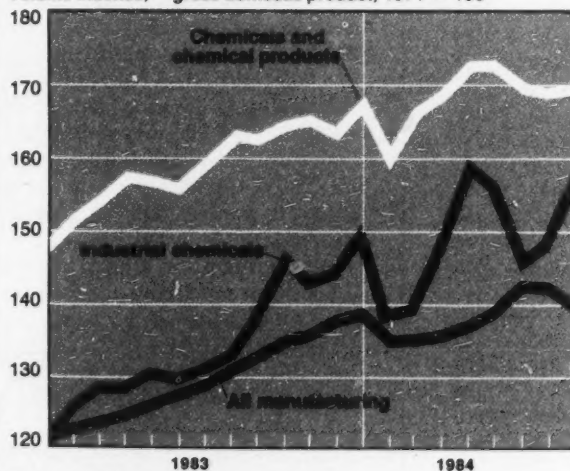


a slowdown, Canadian chemical exports would be in real trouble. A weaker economy at home will only add to the industry's problems.

Provincial governments already are pitching in to help their petrochemical industries. The Quebec government is pumping financial aid (along with some federal funds) into Petromont to keep the petrochemical industry alive in the Montreal area. And the Alberta government is subsidizing the price of natural gas until users and producers can arrive at market pricing arrangements. But the real answer lies in a favorable federal pricing policy for petrochemical feedstocks. □

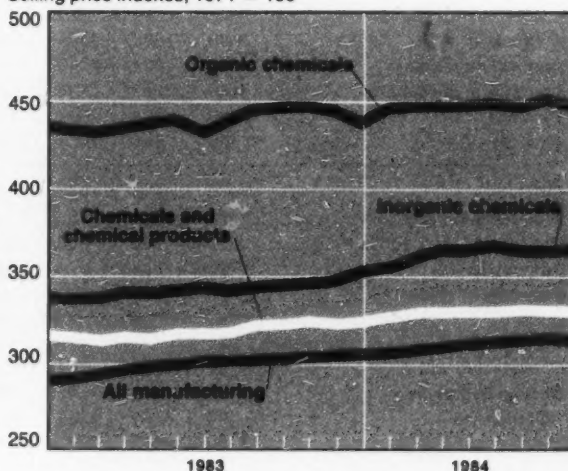
Recovery in chemical output slows . . .

Volume indexes, ^a gross domestic product, 1971 = 100



. . . as prices level out

Selling price indexes, 1971 = 100





U.S.S.R./ EASTERN EUROPE

**Soviet leaders criticize
chemical, petrochemical,
fertilizer industries for
mismanagement, failure
to meet targets**

Richard J. Seltzer, C&EN Washington

The Soviet Union and its six East European allies—Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania—are completing the fourth year of their current five-year plans. Their economies and industry generally picked up in 1983 and 1984, after stagnating or even going backwards during the preceding three years. However, growth continues at a relatively slow pace, and even the modest goals of the current five-year plans seem generally beyond reach.

Gross national product (GNP) for the six East European nations (adjusted for inflation) rose 1.9% in 1983, compared to drops of 0.3%, 1.0%, and 0.8%, respectively, in 1980, 1981, and 1982, according to Central Intelligence Agency calculations. (CIA figures are generally lower than official Soviet statistics because of elimination of double counting and disguised inflation.) The goal was 3.2% for 1983, however.

Similarly, industrial output rose 2.8% in 1983, after zero growth in 1982 and a 2.0% drop in 1981, CIA estimates. (The target was 4% in 1983.)

Following the same trend, Soviet GNP grew 3.0% in 1983, below the goal of 3.3% but above growth of

Five-year plan goals beyond reach in Soviet Union and Eastern Europe

0.2%, 1.7%, 2.1%, and 2.6% in 1979 to 1982. This year, the Soviets expect to achieve their 3% goal. In 1983, industrial output rose 3.7%, exceeding the goal of 3.2% and doubling the 2% growth of 1982. However, this is still far short of the annual growth rate of 4.7% for 1981–85 set by the five-year plan. Moreover, the goal is only 3.8% for 1984 and 3.9% for 1985.

Chemical and rubber output also rebounded in 1983 in most of the six nations, according to official figures. For example, Romania's output rose 6%, Bulgaria's 7%, and Czechoslovakia's 3%, compared to 1%, 6%, and 1%, respectively, in 1982. Countries of the region plan to increase the proportion of plastics, resins, fibers, pharmaceuticals, and cosmetics in their total chemical output.

Soviet chemical output was up 6% last year, slightly surpassing the target of 5.7% per year for 1981–85, after falling far short of it in 1981 and 1982. This year, through October, production is again up 6%, compared to the same period last year. Production of plastics leads the way with an 11% increase. In 1985, chemical and petrochemical industries are to raise output 5%, with fertilizers up 11%, pesticides and plastics up 9%, and caustic soda up 7%.

The Soviet chemical industry has received large investment only in recent years. Its rapid expansion has led to problems in absorbing foreign technology, completing new projects on schedule, and achieving the proper mix of products. Thus, there continue to be shortages of chemical products, such as plastics and fertilizers. Indeed, Soviet leaders recently criticized the Ministry for the Production of Mineral Fertilizers and the ministries of Chemical Industry, of

Petroleum Refining & Petrochemical Industry, and of the Petroleum Industry for mismanagement and failure to meet targets.

Continued growth depends on the Soviets' overcoming such serious problems as slow growth in labor supply, greater difficulty in extracting raw materials and fuels, and the rigidity of central planning and state ownership. Soviet leaders tinker with the current system, instead of seeking structural changes that might threaten party control. However, this year they began an "economic experiment," giving enterprises run by five government ministries more autonomy. The program will be greatly expanded in 1985. □

Plastics lead rise in Soviet chemical production

Thousands of metric tons, unless otherwise noted	10 months 1984	1983	Change 1983–84 ^a
Mineral fertilizers^b	25,600	29,700	4%
Nitrogen (N)	na	13,050	na
Phosphate (P ₂ O ₅) ^c	na	7,350	na
Potash (K ₂ O)	na	9,300	na
Sulfuric acid, 100%	20,900	24,700	3
Synthetic ammonia^d	na	16,770	na
Plastics^e	4,000	4,419	11
Sodium hydroxide, 100%	2,500	2,853	4
Synthetic rubber	na	1,810	na
Chemical fibers and yarns	1,200	1,400	5
Pesticides	481	557	3
Rubber tires	53,100	62,000	3
(thousands of units)			

^a For January–October 1984 compared to same period in 1983. ^b Nutrient content basis. ^c Includes production of ground phosphate rock for direct application and phosphate animal feeds. ^d Nitrogen content basis. ^e Includes resins for man-made fibers. na = not available. Sources: U.S.S.R. Central Statistical Administration, United Nations Economic Commission for Europe (based on official national statistics), Central Intelligence Agency, Department of Agriculture



MIDDLE EAST

**Impact of low-cost
products could alter
balance of global
trade in basic chemicals**

Dermot A. O'Sullivan, C&EN London

Richard J. Seltzer, C&EN Washington

Saudi petrochemicals are about to vie for world markets

demand. The bulk of production, however, will go to Europe, the Far East, and the U.S. Initially, upward to 75% of the marketing likely will be done through SABIC's partners.

SABIC executives insist that they intend to introduce their products in an orderly manner at competitive prices. By inference, this suggests that they are prepared to lower their prices to match any like move by established producers. They will have plenty of room to maneuver in view of their comparatively low production costs.

A detailed analysis compiled by De Witt & Co., Houston, highlights cost discrepancies among production of various petrochemicals in Saudi Arabia and elsewhere. In the case of ethylene, for instance, Saudi product derived from ethane can be made for about 12 cents a lb in contrast to about 20 cents in the U.S., 23 cents in Western Europe, and 25 cents in Japan. Likewise, the 26.7 cent-per-lb cost of polyethylene made in a 220 million lb-a-year unit compares to 40.6 cents in the U.S., 44.9 cents in Western Europe, and 48.8 cents in Japan.

Some observers argue that the large production quantities shouldn't be viewed in isolation. "The reality of the situation," states Mike Hyde, publisher of *Chemical Insight* in London, "is that Saudi Arabia will represent between 2.6 and 2.7% of total world demand of all petrochemicals and plastics. Even against the most pessimistic forecast, that represents no more than one year's growth."

Nevertheless, Tony Church, chemicals analyst at Kidder, Peabody's London office, believes that "Middle Eastern production, especially that in Saudi Arabia, together

with output from other new areas, will have a major impact, changing the whole balance of global trade in basic chemicals. How much this fundamental change in the industry will affect the established producers will depend to a large extent on the reaction of those producers."

Meanwhile, Israel is completing its sixth straight year of triple-digit inflation (190% in 1983). It is also beset by labor unrest, low productivity, declining revenues, rising unemployment, sluggish exports, and diminishing foreign currency reserves. Drastic budget cuts and structural economic reforms are urged on the new government, but there is doubt it is capable of deciding on and implementing such a program.

One step in digging out of the economic crisis is to spur exports, especially from science-based industry. In 1983, Israel produced \$2.9 billion in chemically related products, including \$969 million from minerals and mining, \$558 million in plastic and rubber products, \$552 million in basic chemicals, \$192 million in pesticides, and \$189 million in pharmaceuticals. It exported 55% of its output of basic chemicals, 51% of pesticides, and 22% of pharmaceuticals. In 1983, it invested \$161 million in chemicals (14% of all industrial investment), \$123 million in mining and minerals (10%), and \$52 million in plastics and rubber. And \$150 million is to be invested in pesticide expansion.

Through last September, exports to the U.S. of chemicals, minerals, and plastics rose 56% (to \$109 million). Israel hopes to magnify such exports under a free trade pact now being negotiated. However, U.S. bromine makers seek to exclude their products from the pact. □

Saudi Arabia continues to hold the spotlight in Middle East petrochemicals. Understandably, the prospect of a variety of products made there appearing on world markets as next year progresses is causing concern among established producers, who foresee their domestic and export markets coming under threat.

There's no denying that the capacities of new Saudi plants, in absolute terms, are significant. Two methanol units capable of making 2.75 billion lb a year total already are on stream. By this time next year, Saudi Arabia will have an annual output capability of 829 million lb of caustic soda, 618 million lb of ethanol, 3.54 billion lb of ethylene, 1 billion lb of ethylene dichloride, 1.14 billion lb of ethylene glycol, 200 million lb of high-density polyethylene, 1.31 billion lb of linear low-density polyethylene, 440 million lb of polyvinyl chloride, 649 million lb of styrene, and 660 million lb of vinyl chloride.

Some of the output, made by Saudi Basic Industries Corp. (SABIC) and its joint-venture partners, will meet growing domestic and local regional



BRAZIL

**Sharp rise in exports
brings first chemical
trade surplus, but future
growth will rely more
on sales at home**

Earl V. Anderson, C&EN New York

Next year will be pivotal for Brazil's chemical industry, particularly its all-important petrochemical segment.

For some time now, the industry has been trying to compensate for a stagnant, even declining, domestic chemical market by emphasizing exports. It has been very successful, thanks to government help with export financing and raw material (naphtha) prices.

This year, the industry will achieve its first ever chemical trade surplus. Exports likely will increase a hefty 36% from 1983 to \$1.8 billion, and imports, held in check by government controls, will inch up only 5% to \$1.7 billion.

The resulting \$85 million trade surplus might not sound like much, but considering that the country's chemical industry had a \$2.6 billion trade deficit only four years ago, it is quite an accomplishment.

Next year, however, Brazil's chemical industry may not be able to rely so heavily on exports to keep its plants running at reasonable operating rates. This is especially true for basic petrochemicals and thermoplastics. The reason, of course, is the

Petrochemical producers are seeking to build up domestic markets

long-anticipated debut of petrochemicals from Saudi Arabia on world markets—in many cases the same markets that Brazilian companies covet. But Brazilian companies know they can't compete with Saudi Arabia's feedstock price advantage.

As a result, chemical industry leaders say they will have to start doing next year what they knew they would eventually have to do anyway—rely more on the domestic market for future growth. That prospect leaves many of them understandably nervous.

Now in its fourth year of recession, the Brazilian economy offers little cause for optimism. The country's huge external debt requires domestic belt tightening. Upcoming elections add to the uncertainty.

Despite all this, there are signs that Brazil's economy is starting to stir this year and will grow next year.

Some Brazilian economists estimate that gross domestic product will increase 4 to 6% in 1985.

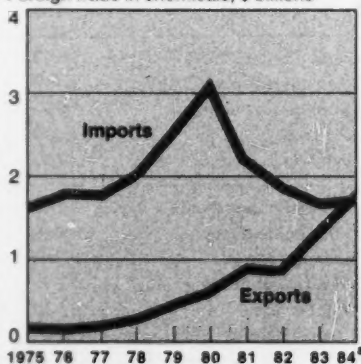
If it does, the petrochemical industry should benefit. This year, only an estimated 60% of production goes to domestic consumption; the remainder is exported. Next year, says Michel Hartveld, director of the Unipar Group, the domestic market's share of output may increase to 66%. Overall, petrochemical production is likely to increase about 10%.

How much headway the chemical industry actually makes in its own home market next year remains to be seen. Gaining ground certainly won't be easy. Rubens Gomes, executive secretary of ABIQUIM (Associação Brasileira da Indústria Química e de Produtos Derivados), the industry's trade association, notes, for instance, that during the past few years, with petrochemical prices rising and unemployment in Brazil running rampant, Brazilians turned from detergents back to soap. Reversing that trend now, even with an improved economy, will be difficult, says Gomes, and it will take time. The same thing has happened to some plastic products, particularly in packaging.

Obviously, exports must remain an important part of the industry's marketing picture for some time. However, like many producers that will have to contend with intense Saudi competition in world petrochemical markets, Brazil's companies are starting to stress the need to export more downstream products. Says one chemical executive, "We have to export more fabricated plastics items, not just the resins." □

Brazil barely gets its first chemical trade surplus

Foreign trade in chemicals, \$ billions



■ C&EN estimate. Sources: Carteira de Comercio Exterior, Banco do Brasil



CHINA

Output of many chemicals already has surpassed five-year plan targets, two years ahead of schedule

Richard J. Seltzer, C&EN Washington

In October, China unveiled what one observer calls "perhaps the boldest experiment ever attempted by a major communist country." Departing from the Soviet development model it has followed since 1949, China plans to curtail central economic planning, give greater autonomy to state-run enterprises, rely more on market forces to determine output and prices, establish incentives for workers, and expand the role of private entrepreneurs.

These sweeping changes accelerate reforms begun in 1979 under China's "economic readjustment" policy. China's program of adjustment and reform is part of an effort to quadruple industrial and agricultural output by the year 2000, putting China among world leaders.

China's strategic planning sets two stages of development, each a decade long. The first covers its sixth (1981-85) and seventh (1986-90) five-year plans. Readjustment and restructuring will continue in 1986-90, but emphasis will shift to large-scale technical transformation of existing enterprises and reform of economic management.

Results so far are on or ahead of

Sweeping economic reforms are aimed at quadrupling production

target in many areas. For instance, total agricultural and industrial production grew 9% a year in 1981-83, versus the moderate target of 4% per year for 1981-85. Industrial output rose 7% a year (the target was 4%). Through October this year, industrial output soared 13% compared to the same period last year.

The chemical industry has one of the highest growth rates of any Chinese industry, paced by large infusions of foreign technology and equipment. Fertilizer output rose 4% a year in 1981-83, compared to a target of 2% a year for 1981-85. Indeed, in 1983, two years ahead of schedule, many chemicals surpassed their five-year-plan targets, including ammonia, fertilizer, sulfuric acid,

sodium hydroxide, plastics, and pharmaceuticals.

Despite its achievements, China still faces major obstacles to economic development, including energy shortages, transportation bottlenecks, lack of raw materials, and bloated investment spending. Capital investment under the current five-year plan gives top priority to energy (26% of the funds) and transportation and telecommunications (13%). Chemicals (5%) also receive priority, with additions to capacity planned for urea (2.2 million metric tons), ammonia (1.5 million metric tons), man-made fibers (380,000 metric tons), sodium carbonate (260,000 metric tons), and ethylene (115,000 metric tons). □

Output of some chemicals already exceeds 1985 targets

Thousands of metric tons, unless otherwise noted	Target 1985	10 months 1984	1983	1982	1981	Change 1983-84 ^a
Ammonia	15,800	na	16,760	15,463	14,833	na
Fertilizers^b	13,400	12,453	13,789	12,781	12,390	6%
Nitrogen (N)	10,550	na	11,094	10,219	9,857	na
Phosphate (P ₂ O ₅) ^c	2,800	na	2,666	2,537	2,508	na
Potash (K ₂ O)	50	na	29	26	20	na
Sulfuric acid, 100%	8,100	6,959	8,700	8,175	7,807	-3
Sodium hydroxide, 100%	2,100	1,847	2,123	2,073	1,923	4
Sodium carbonate	1,900	1,566	1,793	1,735	1,652	5
Plastics	1,050	na	1,121	1,003	916	na
Ethylene	700	526	650	565	505	-1
Synthetic detergents	na	na	677	569	478	na
Man-made fibers	780	588	541	517	527	34
Insecticides	na	280	331	457	484	-6
Pharmaceuticals	47	47	48	42	37	12
Rubber tires (thousands of units)	8,500	13,147	12,710	8,640	7,290	24

^a For January-October 1984 compared to same period in 1983. ^b Nutrient content basis. ^c Including production of ground phosphate rock for direct application and phosphate animal feeds. na = not available. Sources: State Statistical Bureau of the People's Republic of China, Department of Commerce, Central Intelligence Agency

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Scientific meetings Page 34

DECEMBER 24, 1984

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NEWS

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Monsanto R&D

Chief scientist Schneidman,
leads vigorous research push

Page 6

News of the Week

■ Cooperation through chemistry between industrialized and developing nations urged at congress of Pacific Basin countries. **Page 4**

■ Walter Gilbert resigns presidency of Biogen N.V. **Page 5**

■ Remainder of methyl isocyanate in Bhopal, India, plant converted to finished product; Congressman, NTSB urge stronger safety regulations. **Page 5**

Business

Major U.S. chemical companies plan to raise capital spending 17% in 1985 following a mere 2% rise this year over 1983. **Page 16**

Government

Congressional hearing at Institute, W.Va., triggered by the Bhopal tragedy, examines hazards of living near chemical plants. **Page 19**

Company turns more than 3000 tons of state-government-labeled "dangerous waste" into high-quality pelletized fertilizer. **Page 21**

Science

Electron transfer in proteins can occur at biologically significant rates across 10 to 25 Å, three research teams find. **Page 24**

Books

"Newton at the Bat" and "SportScience" use different approaches to describe the role that science plays in sports. **Page 28**

Meetings

C&EN's semiannual calendar of events lists meetings of interest to chemists and chemical engineers during 1985. **Page 34**

Cover: Monsanto senior vice president for R&D Howard A. Schneiderman at St. Louis research lab

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News Focus

Howard Schneiderman, vice president for R&D at Monsanto, discusses the company's new emphasis on R&D and how it will shape Monsanto's future. **Page 6**

Chemical Capital Spending To Climb Again in 1985

Major U.S. chemical firms plan to increase expenditures about 17% in 1985; outlays this year were up only 2% over the 1983 level

William J. Storck, C&EN New York

While many economists are crowing about the good state of capital spending in the U.S. economy, the chemical industry so far is not taking part. Spending in 1984 came in well below first estimates and, as a result, many chemical corporate planners are saying, "Wait until next year." And indications are that things will change next year.

Specifically, C&EN's annual survey of capital spending budgets at 14 leading U.S. basic chemical companies finds a rise of about 17% planned in 1985 from 1984 levels. This follows a preliminary 2% rise in 1984 from what spending was a year ago.

At this time last year, the same 14 chemical companies were predicting that spending on new plant and equipment in 1984 would rise 15% from what they had spent in 1983. However, a number of economic factors conspired to forestall this increase.

Although profits were up for chemical companies, it was accomplished mainly on production, and prices have not especially justified the cost of capital needed to build new plants. Even though production has increased, capacity utilization, except for some few specific chemicals, has not risen high enough to call for new capacity. According to the Federal Reserve Board, capacity use for chemicals and allied products is still only in the mid-70%

range, well below levels needed to justify plant expansion. Though U.S. demand for chemical products has been fairly strong this year, U.S.-produced chemicals have faced increasing competition from imported materials, and U.S. exports of chemicals have been somewhat stifled by the strength of the dollar against foreign currency—a situation that has produced a malaise in U.S. merchandise exports in general.

In addition, the relatively high interest rates prevailing through much of the year have kept the cost of capital relative to expected rates of return on many chemicals too high to justify expansion. Thus, like 1983, this year saw much of the spending on new plant and equipment going to streamlining and modernization in an effort to maintain lower break-even points on products rather than going to building new plants.

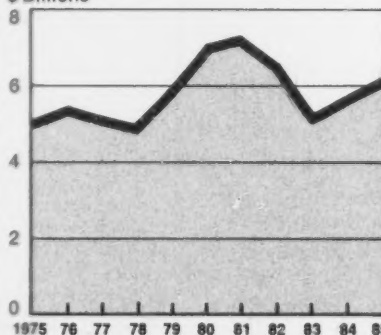
The state of chemical capital spending has led some observers of the industry to become concerned about adequate capacity in the future. After the 1975 chemical recession, they say, there was a spate

of plant building that led to overcapacity throughout much of the late 1970s. The industry appeared to have learned its lesson and after the most recent recession seemed to be very chary of building new plants. In fact, these observers say that the industry may be too timid; they believe that, given the lead time of two to three years to bring a new plant to completion, there could be either a shortage of some chemical products in a few years or the shortfall between demand and capacity will have to be made up by imports, thus shrinking still further the declining chemical trade surplus.

The problem is that most chemical economists see many of the same problems that affected the industry this year prevailing into next year. This means that, no matter what the companies are saying now, capital spending again may increase only moderately. And even if the companies surveyed by C&EN do raise spending an average of about 17%, it still will be well below the 20% pace of the 1970s, when capital spending was fueled by inflation and an unflinching sense of optimism.

Chemical spending will continue to rise in 1985 ...

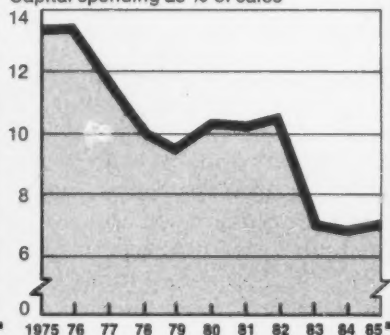
\$ Billions



* C&EN estimate. Source: Combined data from major chemical companies

...and will increase slightly as a percentage of sales

Capital spending as % of sales



Capital spending by major chemical firms will increase to \$6.1 billion in 1985

\$ Millions	1985		1984		1984	Worldwide				Change from previous year	
	World	U.S.	World	U.S.	planned ^a	1983	1982	1981	1980	1985	1984
Air Products	\$ 325	\$ 276	\$ 283	\$ 234	\$ 300	\$ 246	\$ 347	\$ 323	\$ 364	23.8%	6.5%
American Cyanamid	200	150	185	139	190	165	171	181	196	8.1	12.1
Celanese	200	185	170	157	175	105	275	414	253	17.6	61.9
Dow Chemical	830	520	780	450	750	630	829	1176	1184	6.4	23.8
Du Pont ^b	1700	na	1200	na	1500	1276	1300	1420	1297	41.2	-6.0
Ethyl	116	110	86	83	95	85	92	141	156	34.9	1.5
W. R. Grace	420	340	336	267	450	353	560	657	658	25.0	-4.8
Hercules	210	168	200	150	200	168	174	167	229	5.0	19.0
Monsanto	575	523	575	523	600	560	673	668	781	0.0	2.7
Olin	170	165	160	155	175	123	139	186	172	6.3	30.5
PPG Industries	400	320	350	280	400	450	452	376	401	14.3	-22.2
Rohm & Haas	130	104	130	104	130	72	126	182	93	0.0	81.8
Stauffer Chemical	137	117	112	105	130	104	177	239	246	22.1	8.3
Union Carbide	650 ^c	455 ^c	650	455	775	761	1179	1186	1129	0.0	-14.6
TOTAL	\$6063	\$3433	\$5197	\$3102	\$5870	\$5097	\$6493	\$7316	\$7159		
ANNUAL CHANGE ^d	16.7%	10.7%	2.0%	5.1%	15.2%	-21.5%	-11.3%	2.2%	23.5%		

^a Earliest estimates. ^b Excludes Conoco. ^c C&EN estimates. ^d Cumulative change for companies reporting. na = not available.

Even at the beginning of this year, the feeling was that 1984 would take a hefty dose of capital spending—reflected in the 15% increase over 1983 levels planned by the 14 companies surveyed. Preliminary indications of 1984 spending show that it actually amounted to 11% below what had originally been budgeted.

This year, the increase in capital spending was headed by Rohm & Haas, with an 82% jump to \$130 million. This was followed by Celanese, whose spending rose 62% to \$170 million, and by Olin, with a 31% increase to \$160 million. These big increases were offset partially, however, by declines of 22% at PPG Industries to \$350 million, 15% at Union Carbide to \$650 million, and 5% at W. R. Grace to \$336 million.

Some surveys have found that capital expenditures for the chemical industry have increased faster than was found in C&EN's survey. A Conference Board study, for example, shows that capital spending for chemicals and allied products through the first three quarters of 1984 increased 18.4% to \$8.31 billion. However, this is expenditures for the broad chemicals and allied products category and thus includes pharmaceuticals and other specialty products. C&EN's list of companies is dominated by basic chemicals.

On a constant-dollar basis, the

New York City-based business research group's findings indicate that for the first nine months, capital spending for chemicals and allied products rose 18.2% to \$4.26 billion in 1972 dollars, indicating very little construction inflation in 1984.

The 17% average increase in capital spending presently planned for next year cuts across most of the companies surveyed. All of the companies surveyed plan increases in 1985, with the exception of Rohm & Haas, Monsanto, and Union Carbide. These three companies intend to keep spending level with this year. Carbide's spending plans

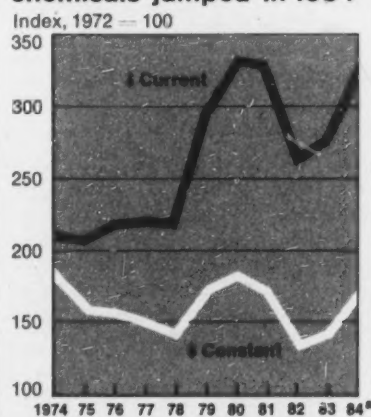
are uncertain, pending the outcome of the Bhopal, India, tragedy.

Du Pont (excluding Conoco) will be leading the increase next year, with a 41% jump to \$1.70 billion, followed by Ethyl, with a 35% increase to \$116 million; Grace, with a 25% rise to \$420 million; and Air Products, with a 24% increase to \$325 million.

Capital spending in the U.S. for the 13 companies reporting these data will increase 11%, slightly faster than their total spending at 9%. Once again about 78% of the spending by these companies will go to plants in the U.S.

Capital spending increases may even be higher over the next few years than the 17% increase for 1985 indicated by C&EN's survey. In addition to surveying capital spending, the Conference Board keeps track of capital appropriations for chemicals and allied products. These monies are what companies currently have appropriated to be spent in the future. The board's survey through the first nine months of this year shows that capital appropriations for chemicals and allied products are up 20% to \$8.80 billion from the same period in 1983, indicating that possibly the next three years or more will be relatively good ones for the U.S. chemical industry in terms of new plants and equipment. □

Capital appropriations for chemicals jumped in 1984



^a C&EN estimate. Source: Conference Board

Bhopal Disaster Spotlights Chemical Hazard Issues

At Institute, W.Va., hearing, government and industry re-examine environmental concerns of communities near chemical plants

Will Lepkowski, C&EN Washington

The world of chemical technology may never be the same, even after public attention veers off from the tragedy at Bhopal, India. Union Carbide chairman Warren M. Anderson agrees. "We're going to have to re-evaluate everything," he told a Congressional hearing in Institute, W.Va., 10 days after the Bhopal disaster (C&EN, Dec. 17, page 6). Institute is the site of Carbide's unit for the production of methyl isocyanate, the chemical that killed at least 2500 persons in Bhopal.

After three weeks of anger, grief, soul searching, and official inquiry, it seems clear that Anderson's promise to look at "everything" will have to include a number of things. For one, evacuation plans for communities near chemical plants. Chemical companies have well-designed and rehearsed plans for preventing and acting on leakages within their plants. And they have siren systems that warn of serious leakages. But the communities themselves have only the scantiest of plans for evacuation procedures once the alarms are sounded. For example, it would make sense for residents of the Kanawha Valley in West Virginia, where Institute is located, to have access to quick rail or water transportation. No such measures exist.

Another area that needs examination is right-to-know laws. In the past, the chemical industry has opposed legislative efforts to tell sur-

rounding communities what is being produced and stored in nearby chemical plants, even though there are worker right-to-know laws on the books.

There is the problem of pollutants from sewage treatment facilities. The Environmental Protection Agency thus far has refused to regulate the mixtures of volatile organic compounds—some carcinogenic—rising into the air from wastewater treatment facilities in chemical plants and in communities where such plants are located. At two Carbide plants, 1990 tons of waste chemicals were discharged into such treatment plants last year, and part of this was released into the atmosphere by aeration, according to Perry Bryant, deputy director of Citizen Action, a public interest group in Charleston.

Another is lowering the high cancer rates associated with chemical production. Some communities near chemical plants are considered cancer "hot spots." Public outcry over such data could rise.

Closing the loops and plugging

the leaks by using more high-technology methods in chemical plants need a look. The industry has made substantial progress in reducing air pollutant emissions. It will have to do better. As West Virginia state health director L. Clark Hansbarger says, "The chemist is obviously going to have to be added to the engineering team in assessing safety and preventive illness activities. We are now going to be dealing with the micro-particle or molecular consistency of our environment, versus dust or haze."

Finally, there is the jurisdictional confusion between the Occupational Safety & Health Administration and EPA. OSHA and EPA will have to do a better job coordinating their functions where public and worker safety overlap. The methyl isocyanate leak that killed the thousands in Bhopal and any other such potential leaks in the workplace are violations that come under the jurisdiction of OSHA. Yet EPA so far is getting most of the heat for failing to list methyl isocyanate as a dangerous pollutant.



Testifying at hearing in Institute, W.Va., are (from left) Carbide's plant manager Henry T. Karawan, chairman Warren M. Anderson, and director of health and safety Jackson B. Browning

"It's a terrible thing to think we have to have these tragedies to get industry to come forward and say, yes, maybe we should have thought these things through," declared Rep. Henry A. Waxman (D-Calif.), chairman of the House Health & Environment Subcommittee that held the hearings. "On those areas—right to know, air emissions, and underground storage—it has not been the posture of the industry to be as accommodating as you [Anderson] are today. I'm hopeful you can share that attitude and try to induce the rest of the industry to be a little more forthcoming and not automatically be opposed to many of the initiatives."

Testimony from school teacher Donald Wilson underscored the kind of extreme, but measured, response the industry can expect in coming months from a concerned public. Wilson was describing his experiences during an atmospheric inversion in Institute. He reported several days of flu symptoms in himself and his students.

"I became alarmed because I knew that these experiences were taking place on such a magnitude and were not being reported," he said. "As fluid developed in our lungs we learned to sleep on an incline to keep from drowning in our own fluids. We have learned to stay inside when there is no wind and to keep plenty of moisture in the home."

"This is what you call the risk factor and this is what the risk factor means to me. I teach in Stonewall Jackson High School in the heart of the so-called 'cancer superblock.' I have watched our children come to school with arthritis, with cancer, with leukemia at a rate much higher than the national average. Only over the last few months have we heard any indication from so-called experts making reference to the studies that have been done in the area."

So the Kanawha Valley will be the place to watch over coming months for the combined response of industry, government at all levels, and the public as to the overall occupational and environmental health aspects of chemical exposure.

The fact is that several areas of the valley are not pleasant places to

Carbide's Institute plant emits major pollutants

Pollutant	Pounds per hour
Acetone	346
Acrylonitrile	36
Benzene	72
1,3-Butadiene	127
1,3-Dichloropentadiene	96
Ethylene oxide	443
Formaldehyde	67
Hydroxyethylcellulose	66
Isopropanol	665
Kerosene	36
Methanol	133
2-Methylbutene	351
Methyl isocyanate	12
4-Methyl-2-pentanone	76
Nitrogen dioxide	12
Propylene oxide	252
Toluene	22

Based 1981 survey of major emissions from plant. Source: Occupational Safety & Health Administration

live, especially in winter. Skies are often overcast, the air is often still, mist settles like a napping cat over the landscape. The residents are staunch, loyal to their life-blood industries, and impressively open hearted. Few speak up, although statistics and anecdotal evidence show that their health and environment could be better.

Admittedly, the Kanawha River itself is cleaner than it has been in 50 years. So is the air. The only vapors seen wafting up from the chemical plants appear to be steam. But as Bryant testified, the dangers now are even more insidious. The respiratory cancer rates in the valley are 50% higher than the national average, according to state health statistics. Sewage treatment, he said, is especially lax.

"The citizens of the Kanawha Valley, who are forced to assume the risk of storing chlorine, phosgene, methyl isocyanate, and other toxic substances within their community," said Bryant, "have no way whatsoever to obtain this information under existing law. Nor do they have any input into the decision to store superhazardous materials within their community. We find this to be an unconscionable situation, one that must be changed."

The West Virginia air pollution

control law requires plants like Carbide's to list an inventory of toxic materials escaping from their facilities. For Institute, "this inventory indicates that there are hundreds of pounds of toxic gases that are leaking every day," said Waxman. "If that is accurate," he asked Anderson, "do you know whether those leaks are causing cancer, central nervous disorders, birth defects, or other dangers to the public health over a longer period of time?"

Anderson, of course, didn't have the answer. But he said industry is getting better at controlling leakages. If that's so, said Waxman, "you're doing it without knowing what is happening. We're being told on the one hand that it's a sealed system. But on the other, all these chemicals are leaking into the air on a routine basis. I find that troubling. The federal government doesn't know anything about it and that's outrageous enough. The state government hasn't the ability to regulate. We rely on you to regulate yourself. And if you are regulating yourself, it doesn't seem to me that your own people know why these chemicals are going into the air and what effect they're having on the public."

Anderson insisted he had "no objection" per se to any right-to-know law. "My concern is state-level right-to-know laws that confuse and complicate the issues. A federal right-to-know law that could be actively administered and [that] everyone understands and could be worked with makes sense," he said.

"If anything has come out of Bhopal," he continued, "it is the re-evaluation by government agencies, by industries themselves, what is it that we have, what is it that we need, how do we ensure against tragedies such as Bhopal. As I have said before, I never would have believed that this sort of thing could have happened. But it did. We don't know why. Maybe when we do, it will give us guidance and direction in which way we and a lot of other people should move."

"I don't know what the answers will be. I know that probably that the rest of my career will be involved in this kind of a discussion and resolution of issues." □

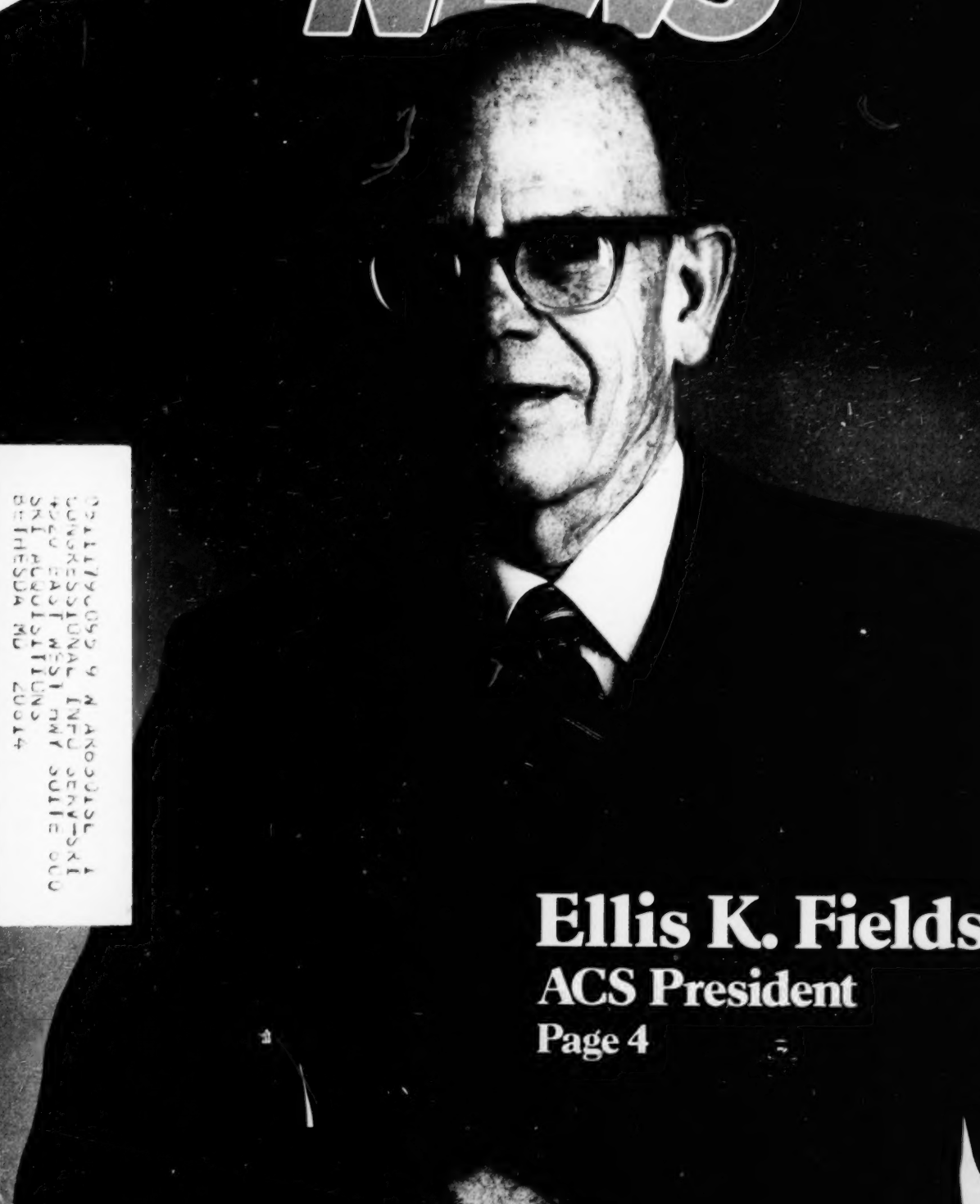
Scientific news from the
PAC CHEM '84 meeting in Honolulu

JANUARY 7, 1985

CHEMICAL & ENGINEERING

NEWS

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A black and white portrait of Ellis K. Fields, a man with glasses, wearing a suit and tie, looking slightly to the left.

Ellis K. Fields
ACS President
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News of the Week

■ Federal agencies that will regulate products of biotechnology and genetic engineering issue policy statements. **Page 8**

■ Major interdisciplinary research effort on adhesives urged in report by NRC. **Page 9**

■ Outlook for college graduates this spring includes more job offers, higher starting salaries. **Page 9**

■ China joins international convention for protection of patents and trademarks. **Page 9**

■ Photographs show variety of people and events comprising 1984 International Chemical Congress of Pacific Basin Societies. **Page 10**

■ Officers of PAC CHEM '84 send personal message to India's Prime Minister Rajiv Gandhi about Bhopal tragedy. **Page 12**

Cover: Photo by Greg Pease

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Business

Growth rate for chemical industry productivity, behaving erratically in recent months, is causing concern. **Page 21**

International Business

Dutch firm Akzo Chemie aims for balance in geographical areas and product lines in its expansion policy. **Page 24**

Government

Biotechnology regulation moving ahead after recent Congressional hearings; careful coordination among agencies needed. **Page 27**

Science

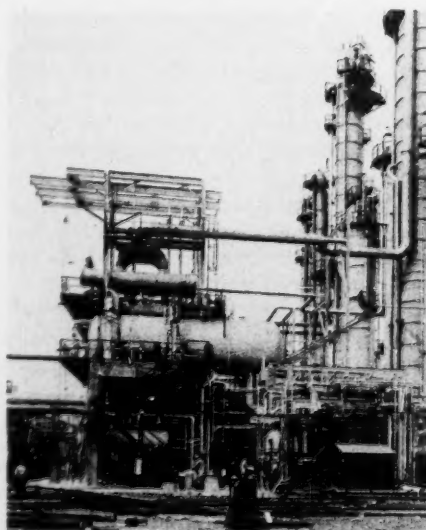
News from PAC CHEM '84: Chemical signals for predicting earthquakes; folk medicine as basis for new drugs; computer-based sound systems; concerted-twist mechanism; new perfluoroalkenyl reagents for synthesis; active metabolites of vitamin D₃; affinity partitioning method of cell separation. **Page 32**

Technology

From Honolulu: South Africa's Sasol Technology to produce more diesel fuel; Texaco Chemical develops versatile bimetallic catalysts; Union Carbide's new molecular sieves. **Page 45**

News Focus

Reshaping of chemical industry for industrialized and newly industrialized countries over remainder of the century is foreseen at PAC CHEM '84. **Page 13**



NRC report urges research on adhesives

The Department of Defense and the National Aeronautics & Space Administration are both quite interested in replacing mechanical fastenings with adhesive bonds because of potential savings in weight and manufacturing costs.

Such bonds have proved to be quite reliable under favorable conditions. But it has not been proved that adhesive bonds can meet the required 30-year durability test under conditions of high humidity, high temperature, and sustained loads.

What is needed, according to a report just issued by the National Research Council, is a major interdisciplinary research effort, spearheaded by the federal government. That effort should involve material science, surface science, mechanics, and process engineering. And it should recognize that adhesive bonding must be studied as a complete system.

The report, "Reliability of Adhesive Bonds under Severe Environments," grew out of a workshop organized by an NRC committee of the same name, chaired by Serge Gratch, director of Ford Motor Co.'s material and chemical sciences laboratory, and attended by about 100 invited experts. It was sponsored by DOD and NASA. A number of specific research recommendations in the fields of chemistry, interfaces, and mechanics were formulated during the workshop.

The recommendations for chemical research include:

- Synthetic work should be performed to investigate polymer-forming reactions that eliminate evolution of volatiles and provide moisture-resistant polymers with a favorable combination of adhesive properties.

- Basic synthetic work should be directed toward elimination of tenaciously held and toxic solvents, especially for high-temperature polymers.

- Studies on model high-temperature polymers should be conducted to generate fundamental information on the relationships among

structure, cure, physical properties, and mechanical properties.

- New synthetic routes should be investigated to circumvent the need to use toxic monomers.

- Research should be aimed at toughening the adhesives, improving the processability of high-temperature adhesives, developing adhesives that alleviate the shortcomings of conventional epoxy adhesives, and studying crosslinking mechanisms to obtain fast-curing adhesives with no volatile products. □

Job outlook is good for spring grads

More job offers and higher starting salaries likely will face next spring's college graduates, according to Northwestern University's 1985 Endicott Report, an annual survey of the employment intentions of 250 medium-sized and large U.S. corporations.

The students will reap the benefits of the business community's strong confidence in continued economic growth into 1985. "The majority of firms snapped back from a mediocre 1983 and had a good year in 1984," says Victor R. Lindquist, director of placement at Northwestern and author of the report. "And they expect 1985 to be even better."

That confidence will translate into more job offers. "Corporations expect to hire 15% more students with bachelor's degrees and 13% more with master's degrees," Lindquist says. "Sixty-two percent of the firms will need more graduates with bachelor's degrees, and 44% will need more students with master's degrees."

He points out that "The confidence in the nation's economy by firms' personnel executives is contrary to the views of many professional economists who feel high interest rates, the federal deficit, and declining consumer demand will flatten the economy in the last two quarters of the year and perhaps be the beginning of a new recession." Should such forecasts begin to come true, he says, corporations could immediately slow down their hiring of college graduates.

Starting salaries will be up this year for college grads

	1984	1983	% change
BACHELOR'S DEGREE			
Engineering	\$25,856	\$26,390	4.8%
Accounting	19,884	20,828	3.7
Sales-marketing	20,040	20,616	2.9
Business administration	19,656	19,896	1.2
Liberal arts	18,840	18,828	0
Computer	22,860	24,156	5.7
Chemistry	23,280	24,216	4.0
Mathematics or statistics	22,140	22,704	2.5
Economics or finance	20,040	20,984	4.6
Other fields	20,484	21,972	7.3
MASTER'S DEGREES			
Engineering	29,532	30,900	4.6
Other technical fields	27,972	29,724	6.3
MBA with technical BS	30,228	31,800	5.2
MBA with nontechnical BA	28,440	30,348	6.7
Accounting	24,960	26,676	6.9
Other nontechnical fields	25,104	26,496	5.5

For bachelor's candidates, the biggest increase in job offers will be in the disciplines of economics and finance, up 65%, and business administration, up 33%. Engineering also will benefit, up 18%, and so will sales and marketing, up 14%, and computers, up 11%. At the master's level, demand for accounting majors will be especially strong, with 52% more offers going to next spring's graduates.

Salaries, too, will be up this year, Lindquist says. The biggest gains will be for graduates with master's degrees, where accounting majors' salary offers will be up almost 7%. At the bachelor's level, chemistry majors can expect a 4% increase in salary offers, and engineering majors a nearly 5% increase. □

China joins treaty on patents and trademarks

China has joined 95 other nations in becoming a party to the Paris Convention for the Protection of Industrial Property, the major international treaty on patents and trademarks. China's accession will take effect on March 19, 1985, shortly before its first patent law goes

Chemical Productivity's Erratic Pattern Causing Concern

William J. Storck, C&EN New York

As the U.S. economy continues to recover and talk abounds of a possible slowdown, some economists are closely watching productivity as an indicator of what may lie ahead. In the past, a slowdown in productivity growth or a decrease in productivity often has been a harbinger of a stagnating economy.

But so far, it's difficult to conclude much from figures available, especially about the chemical industry's productivity. Through the first

nine months of 1984, productivity (output per workhour) in the country's entire manufacturing sector (including the chemical industry) increased from the previous year's nine-month period, as did productivity in the chemicals and allied products sector alone. However, on a quarter-to-quarter basis, productivity growth for all manufacturing has been increasing modestly, but for the chemical industry, that growth has been erratic.

Using government data for production and workhours, C&EN cal-

culates that chemical productivity in the first three quarters of 1984 increased 5% to an index of 230.7 (1967 = 100) from the same period in 1983. At the same time, productivity for the all-manufacturing sector increased just 1.2% to an index of 177.6.

But it has not been an even course for chemical productivity. After its growth rate dwindled consistently throughout much of 1983, productivity actually fell in the first quarter of 1984. It then rebounded in the second quarter to a 2.6% increase

Productivity has risen slightly after first-quarter slump . . .

Indexes, 1967 = 100	Quarters, 1984			Quarters, 1983				Quarters, 1982			
	3rd	2nd	1st	4th	3rd	2nd	1st	4th	3rd	2nd	1st
CHEMICALS AND ALLIED PRODUCTS											
Production	231.5	229.1	223.8	225.0	220.9	211.4	201.9	194.2	195.4	195.1	199.4
Workhours	100.3	100.0	100.2	99.1	98.2	97.6	96.5	97.0	98.4	99.7	101.7
Productivity	230.7	229.1	223.3	227.1	225.0	216.5	209.1	200.3	198.6	195.7	196.1
Hourly production wages	359.8	355.1	352.3	350.0	343.1	338.8	335.1	331.3	324.8	317.6	312.3
Unit labor costs	156.0	155.0	157.7	154.1	152.5	156.5	160.2	165.4	163.6	162.3	159.2
ALL MANUFACTURING											
Production	167.2	164.4	161.0	156.6	152.8	145.2	138.4	134.4	137.7	138.1	139.8
Workhours	94.1	94.4	93.5	91.1	84.8	85.4	82.6	81.7	84.2	86.7	88.3
Productivity	177.6	174.2	172.1	171.9	180.3	170.1	167.6	164.4	163.6	159.2	158.5
Hourly production wages	325.5	323.4	321.9	318.1	313.4	311.0	309.2	305.3	303.0	299.9	297.0
Unit labor costs	183.3	185.7	187.0	185.0	173.8	182.8	184.5	185.7	185.2	188.4	187.4

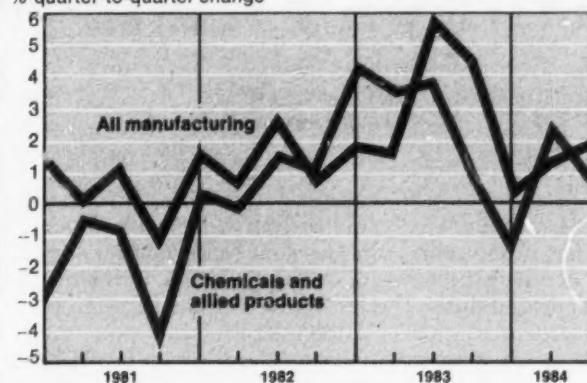
. . . and for first three quarters of 1984, it continues climb from prerecession doldrums

Indexes, 1967 = 100	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
CHEMICALS AND ALLIED PRODUCTS											
Production	228.1	215.8	196.1	215.6	206.6	210.4	197.4	185.7	170.9	147.2	159.4
Workhours	100.2	99.1	99.6	105.9	105.1	107.4	106.5	104.2	101.4	96.5	105.1
Productivity	227.7	217.8	196.9	203.5	196.6	195.9	185.4	178.3	168.6	152.6	151.7
Hourly production wages	355.7	341.6	321.3	294.2	267.7	245.2	226.5	207.4	190.6	173.9	157.4
Unit labor costs	156.2	156.8	163.2	144.6	136.2	125.1	122.1	116.3	113.1	113.9	103.8
ALL MANUFACTURING											
Production	164.2	148.3	137.6	150.4	146.6	153.2	146.8	138.4	130.3	116.3	129.4
Workhours	94.0	87.6	85.6	96.0	97.0	104.1	102.5	98.0	94.2	88.6	100.9
Productivity	174.6	169.2	160.8	156.7	151.2	147.1	143.3	141.2	138.3	131.2	128.2
Hourly production wages	323.6	313.5	301.4	283.3	257.8	237.6	218.8	201.4	185.1	171.3	156.7
Unit labor costs	185.3	185.3	187.5	180.8	170.5	161.5	152.7	142.7	133.9	130.5	122.3

^a First nine months. Sources: Department of Labor, Federal Reserve Board

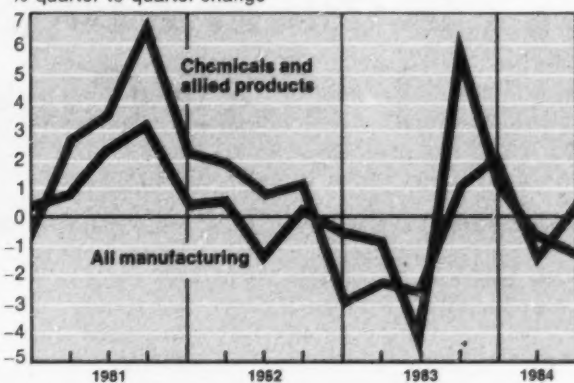
Quarterly gains in chemical productivity have lagged those for all manufacturing ...

% quarter-to-quarter change



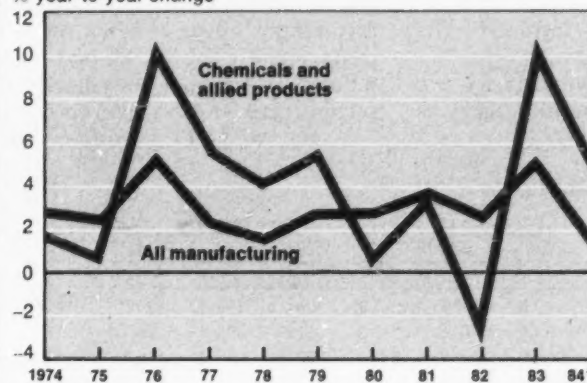
...giving faster rate of increase for chemical unit labor costs in past four years

% quarter-to-quarter change



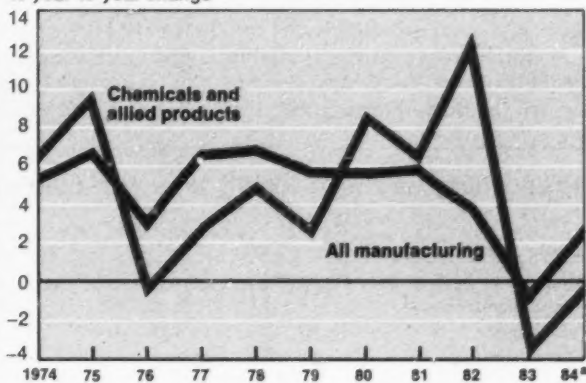
But in 1984, productivity for chemicals rose faster than that for all manufacturing ...

% year-to-year change



... helping to lower chemical unit labor costs, though only slightly

% year-to-year change



a First nine months of 1984. Note: Productivity is output per workhour, calculated by dividing indexes for production by indexes for workhours of production employees. Unit labor costs are labor costs per unit of output, calculated by dividing indexes for wages by indexes for output per workhour. Sources: Department of Labor, Federal Reserve Board

and once again slowed in the third quarter to an increase of just 0.7%.

All manufacturing showed the same growth slowdown during 1983 and through first-quarter 1984, but its productivity never declined. In addition, since the first quarter, its growth rate has been rising modestly, up 1.2% in the second quarter and 2.0% in the third quarter.

Unit labor costs (production wages per unit of output) for the chemical industry give a picture that is little better. Unit labor costs in the first nine months of 1984 declined just 0.1% to an index of 156.2 (1967 = 100) from the same period the year before. However, on a quarter-to-quarter basis, unit labor costs in 1984 declined only in the second quarter, although in the third

quarter they were up just 0.6% to an index of 156.0.

This is in contrast to all manufacturing, for which unit labor costs declined 0.7% in the second quarter and 1.3% in the third quarter to an index of 183.3. Nonetheless, unit labor costs rose 2.7% in the first nine months of 1984 to an index of 185.3, up 2.7% from the same period the year before.

Although chemical productivity remained at a 5% increase through the first nine months of 1984, the downward trend in the quarter-to-quarter changes bodes ill for a continuation of this 5% rate through the next year, let alone the next two years, unless something happens to boost chemical demand. Chemical workhours have remained

fairly stable during the first nine months.

Some economists still are predicting that productivity in the general economy will increase, and it can be hoped the chemical industry will be pulled along on its coattails. For instance, the Conference Board said in a report late last month that U.S. productivity growth, which it called dismal over the past decade, is poised for a significant, long-term turnaround.

The New York City-based business research group says that the broadest measure of productivity in the private business sector rose 2.9% in 1983, one of the steepest jumps since World War II. And it predicts another impressive gain when final results are in for 1984. □

More scientific news from
PAC CHEM '84 in Honolulu

JANUARY 14, 1985

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Congressional Outlook '85

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News of the Week

■ Union Carbide's Warren Anderson explains strategy following Bhopal accident. **Page 6**

■ Annual forecast by Battelle predicts U.S. expenditures surpassing \$107 billion for R&D in 1985. **Page 7**

■ Monsanto plans field testing for genetically engineered soil microbe. **Page 7**

■ EPA announces proposal to help refiners meet standards for reducing lead use in gasoline. **Page 8**

Cover: Old Senate chamber in the U.S. Capitol. Photo by C&EN's David Harrison

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Business

U.S. chemical firms will boost R&D spending an average of 9% in 1985; Du Pont and Monsanto are biggest spenders. **Page 19**

Science

From PAC CHEM '84: electrochemical processes to make organic commodities, and for bioanalysis; spectroscopic techniques for inorganic labs; electron transfer reactions in model systems; synthetic hemoglobin; solvation of electronically excited solute molecules; simulated ocean floor to study cell origin; study of trivalent chromium interaction with living cells. **Page 29**

Technology

From Honolulu: science/technology's role in helping developing countries; catalysts selectively activate C-H, C-C bonds; trace analysis of manganese; reagent for copper extraction; cost studies on fuel from corn waste; analyzing coal macerals; microsensors for chemical analysis; raising GC sensitivity by thermal modulation; carrier enhances chromatographic separation. **Page 48**

Books

"America's Third Revolution" treats relationships among business, government, and society; Consumer Product Safety Commission guide discusses hazardous substances in school labs. **Page 70**

ACS News

Petroleum Research Fund grants totaling more than \$4 million have been approved by the ACS Board of Directors. **Page 75**



News Focus

The 99th Congress faces many issues: the federal deficit, chemical-biological warfare, reauthorization of environmental laws. **Page 10**

ations or litigation in the future. He did not say any negotiations are under way at present between Carbide and Indian parties, but he says he thought the Indians were listening to his requests for such talks.

"The issue has been: How do you get all those people represented in a negotiation rather than in a confrontation? That's what we've been working on," he says.

As a sign of possible rapprochement between the company and Indian authorities, Anderson revealed that Carbide's offer of \$1 million for immediate relief assistance to India—a check that was rejected when first proffered shortly after the accident—has now been accepted by the prime minister's office in New Delhi "within the past week." A similar check for \$840,000 from Union Carbide India offered to the state government of Madhya Pradesh apparently has not yet been accepted. Anderson stresses that the aid has nothing to do with potential compensation and says the original rejection of the relief funds was due to a misunderstanding of the company's motives.

Anderson also says that another good sign was news last week that the attorney general of India, K. Parasaran, would be visiting the U.S. soon to discuss jurisdiction issues. He says he hopes the visit, in which the Indian attorney general is expected to meet with American legal experts, will persuade the Indians to work toward settlement rather than to trust to litigation. He did not say whether he or Carbide representatives will attempt to meet the attorney general in the U.S.

In its efforts to foster negotiations, the chairman says, Carbide investigated the use of intermediaries but decided to let its own employees do the talking. On the other hand, the \$1 million relief check was presented to the Indian government on behalf of Carbide by the U.S. ambassador to India, Harry Barnes, according to Carbide. Questions as to whether the State Department was involved in other ways, particularly in helping set up negotiations between the involved parties, received noncommittal answers from both Carbide and the State Department in Washington,

which says it did not even know that Ambassador Barnes had presented the check. It also is unclear whether the Indian attorney general's plan to visit the U.S. might have come in response to U.S. urging.

In talking about the difficulty of creating just the framework for a settlement, Anderson says that the rush of U.S. personal injury attorneys to Bhopal had "confused the issue over there" and implied that the settlement process probably would be further along if they had not intruded. Anderson repeatedly has said that he considers India the proper place to work out a settlement and for litigation. Observers outside the company just as repeatedly have noted that it undoubtedly would be less costly for Carbide if India were to retain jurisdiction.

On another key issue—that of what precisely happened at the

plant—Anderson explains that because of incomplete access to personnel and the plant, Carbide's investigation of the accident's cause probably will take another four to five weeks. He says he feels "reasonably sure" that the company will have an answer within that period.

Pointing out that many multinational manufacturing companies probably will be reappraising their overseas strategies as a result of the accident, Anderson also says that some good probably will emerge from the tragedy. "We have a commitment and an obligation to lead the way, if we can, to how we will now worry about safety," he says. "The world's going to be a better place. It's a hard way to learn a lesson, but if you went through a disaster like this and didn't learn anything, that would be the worst," he adds. □

R&D funding predicted to rise 11% in 1985

Research and development expenditures in the U.S. will surpass \$107 billion in 1985, Battelle Columbus Laboratories says in its annual R&D forecast. That will be \$10 billion (11%) more than the \$97 billion that the National Science Foundation estimates actually was spent for R&D in 1984. Battelle adds that the real increase will be on the order of 3.9%, assuming a 6.5% inflation rate.

Of the total, industry will furnish \$55 billion (51%), the federal government \$49 billion (45%), colleges and universities almost \$2.3 billion (2.1%), and other nonprofit institutions slightly more than \$1.3 billion (1.2%). Until 1979, Battelle notes, the government provided

more funds for R&D than did industry. But during the past decade, real R&D support has grown an average 5.4% per year (compounded) for industry, compared to 3.0% for government.

According to Battelle economists Jules J. Duga and W. Halder Fisher, industry will spend 11% more on R&D than in 1984. Eight broad industrial sectors each will spend more than \$1 billion. Biggest spender will be the aerospace industry, with projected expenditures of \$20 billion. But almost 76% of that will come from government, only 24% from the industry itself. In contrast, R&D in the other seven sectors—electrical machinery/communications, ma-

Chemicals R&D most heavily self-funded sector in 1985

\$ Billions	Total funds	Industry funds	Government funds	Industry share
Aerospace	\$20.01	\$ 4.87	\$15.14	24.3%
Electrical machinery/communications	16.94	11.28	5.68	66.5
Machinery	9.79	8.86	0.93	90.5
Chemicals	8.94	8.43	0.51	94.3
Transportation equipment	7.21	6.38	0.83	88.5
Instruments	5.47	4.63	0.84	84.6
Petroleum products	2.58	2.34	0.23	91.1
Rubber products	1.49	1.07	0.42	71.7

Source: Battelle Columbus Laboratories

chinery, chemicals, transportation equipment, professional and scientific instruments, petroleum products, and rubber products—will be heavily self-funded, with, on average, 82% of the total coming from the industries and only 18% from government. (For more on chemical industry R&D spending, see page 19.)

Battelle attributes the increase in industrial R&D support to a number of factors, including a good economic climate, response to foreign competition, and a lowering of barriers to cooperative research programs. Also, there are early indications that new financing methods (such as the R&D limited partnership) may be having an effect on total R&D spending.

The projected \$49 billion federal contribution represents a 10% increase from 1984. The Department

of Defense will account for 66% of the total, compared to 62% in 1984. Support of energy R&D will decline, except for defense-related and selected conservation programs. With the National Aeronautics & Space Administration's space shuttle program almost out of the R&D stage, NASA funds will shift to other areas, such as the space station. And, Battelle says, "continuing de-emphasis will be found on research in the 'soft' sciences, including those areas that support the environmental, ecological, and socioeconomic impact investigations presently mandated by law."

Regardless of the source of R&D funds, industry will do most of the actual work—75% of the total. Of the rest, in-house government R&D will account for 11%, academic institutions about 12%, and other non-profit organizations about 3%. □

Plan may help refiners meet lead-in-gas rules

The Environmental Protection Agency announced last week a "banking" proposal that it claims would help refiners and importers meet expected new standards that will reduce the amount of lead additives allowed in gasoline.

The proposal would give industry the flexibility of reducing lead use in gasoline this year below the current standard (1.1 g lead per gal of gasoline) and bank, or obtain credit, for the difference. This banked credit could be used later by a refiner to meet stricter standards, or the refiner could sell the credits to other refiners or importers.

The agency has said refiners can begin accumulating credits as of Jan. 1, but cannot use them until the second reporting quarter of 1985. The proposed scheme would become ineffective by the end of 1987, presumably when the strictest standard (0.1 g of lead per gal of gasoline) is in place.

EPA is taking action to control airborne lead because of the metal's adverse effects on health.

The agency is expected to promulgate a rule lowering lead use in gasoline by the end of this month, or early in February, says chief of EPA's fuels branch Barry D. Nussbaum. He is unwilling to say whether the new standard would be 0.1 g per gal, effective next year, or a gradual phasedown to that level by Jan. 1, 1988.

Without knowing exactly what rule EPA will establish, the agency is "establishing a bank without knowing the rates," Natural Resources Defense Council attorney Eric Goldstein says. "Banking as a concept is an innovative way of regulating. It makes sense in some cases," Goldstein says. "But without knowing the ground rules of EPA's overall [lead phasedown] program, it is hard to know whether the banking proposal is strictly confined, well documented, and purports with the law," he adds.

EPA will hold a public hearing on its banking proposal Jan. 15 in Washington, D.C. □

Monsanto to field test gene-modified pesticide

Monsanto has notified the Environmental Protection Agency that it plans to field test this spring a soil microbe that has been genetically engineered to make a protein insecticide. The microbe is *Pseudomonas fluorescens*, a common colonizer of corn and soybean root surfaces.

Monsanto scientists used a plasmid to insert the endotoxin gene from *Bacillus thuringiensis* into the genome of the soil microbe. *B. thuringiensis*, available in the U.S. from Abbott Laboratories and Sandoz, has been registered in this country for insect control on plant surfaces above ground for more than 20 years.

Robert J. Kaufman, Monsanto's director of plant science research, emphasizes that the engineered *P. fluorescens* is only a prototype of broader spectrum microbes the firm plans as products. The endotoxin is most potent only against lepidopteran insects. The black cutworm, which attacks roots of corn and soybeans, is one of these. Either genes for more toxins will have to be inserted into *P. fluorescens*, or blends of microbes that make other toxins must be developed. Monsanto will not have actual product candidates until 1986, Kaufman says, and test-

ing will delay introduction of these until 1988.

Testing will take place in a diked, 1-acre field at Monsanto's St. Charles, Mo., research farm. Microbe-coated seed corn will be sown on a 0.3-acre experimental plot. Investigators will compare emergence of seedlings and eventual root damage in the experimental plot with those in a control plot. The diking is part of an effort to prevent spread of the engineered microbe from the field. Workers will have a methyl bromide fumigant ready if evidence of spread appears.

Another question is persistence of the engineered microbe. Previous tests indicate that it does not survive longer than eight to 14 weeks, and that it does not persist over winter. Such tests also suggest that the engineered *P. fluorescens* is equally or less competitive with other microbes than the wild strain. Thus it may not overgrow and disrupt the natural balance of soil organisms.

Monsanto sent its notification and data to EPA following an October 1984 policy statement by that agency claiming jurisdiction over genetically engineered pesticides (C&EN, Oct. 15, 1984, page 4). □

Chemical Industry Will Spend 9% More on R&D in 1985

Big increases by Du Pont and Monsanto, spurred by research pushes in life sciences, highlight a mixed bag of spending plans

David Webber, C&EN New York

There is a technology race on in the chemical industry, and companies are spending money to win it. Du Pont and Monsanto, both of which opened big, expensive life sciences research facilities last year, are planning to add generous amounts of money to their research budgets this year. Several other firms, while planning to increase their research and development expenditures by smaller sums, also will raise their budgets more than 10%. It is all part of a trend that, although evidenced unevenly within a group of 14 selected chemical producers, reflects a general move to greater emphasis on R&D in the chemical industry.

The composite 9% increase in the representative group's R&D budgets for 1985 undoubtedly will raise the percentage of sales that the industry spends on research above the 4.1% attained in 1984. That share, considered a rough yardstick of relative interest in R&D, has grown steadily since reaching a recent low of less than 2.7% in 1978. In 1983, R&D spending as a per cent of sales nudged 4.0%.

The composite budget increase also means that chemical industry spending on R&D continues to grow in real terms. According to Battelle Columbus Laboratories, industrial R&D inflation in 1985 will amount to some 6%, giving the group an adjusted increase of 3% for the year.

At the same time, however, employment of R&D scientists and engineers by the chemical industry seems to have peaked after several years of strong growth. The National Science Foundation reports that the number of such positions in the basic chemical industry dropped to 26,700 at the beginning of 1984 from 27,200 at the beginning of 1983. Recent indications from one major barometer of R&D hiring—the high-technology recruitment index maintained by the New York City consulting firm Deutsch, Shea & Evans—suggest that the pace of employment has reached a plateau.

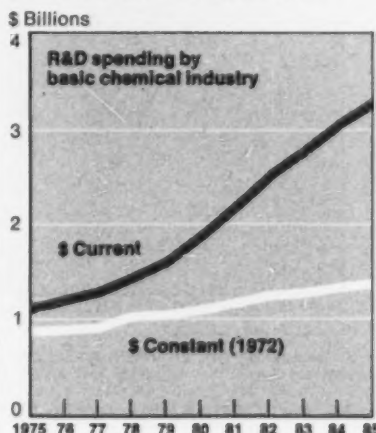
This is not to say that firms will be hiring no new scientists at all. Monsanto, for one, says it plans to add some 600 employees to the research staff at its new life sciences research center outside St. Louis over the next few years. In general, however, the drop in NSF's tabulation of chemical R&D jobs suggests that firms will be spending more of their budget increases on research equip-

ment and materials than on new scientists and support staff.

Monsanto and Du Pont continue to dominate the acceleration of chemical research spending. Du Pont, far and away the heaviest chemical R&D spender in the U.S., laid out \$1 billion on R&D in 1984—excluding additional funds devoted to energy-related research conducted by Conoco. As a result, Du Pont (excluding Conoco) devoted an estimated 6.2% of last year's sales to R&D, a share that begins to approach levels customarily more typical of pharmaceutical than chemical firms. In 1985, Du Pont intends to boost research spending another \$100 million, an increase that by itself will total more than the entire research budget of many a chemical producer.

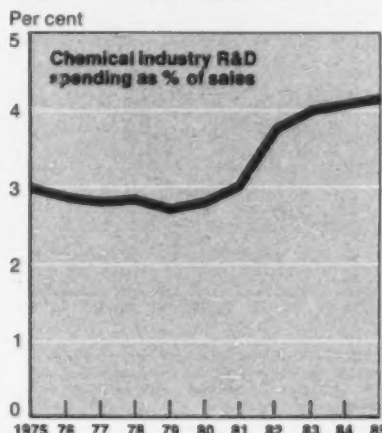
Monsanto, which increased its R&D spending a third in 1984, has budgeted (according to preliminary estimate) as much as another 17%, or \$65 million, for 1985 for a total of \$450 million. In 1984, the com-

R&D budgets are rising faster than inflation ...



Sources: C&EN surveys, Battelle Columbus Laboratories

...and surpass 4% as share of corporate sales



Larger share of sales was spent on R&D in 1984

\$ Millions	Planned 1985	Actual 1984	Planned 1984	1983	1982	1981	1980	1979	Change from previous year		R&D spending as % of sales	
									1985	1984	1984	1983
Air Products ^a	\$ 51	\$ 44	\$ 42	\$ 40	\$ 37	\$ 32	\$ 30	\$ 24	16%	10%	2.5%	2.4%
American Cyanamid	250	240	235	215	190	172	148	130	4	12	6.2	6.1
Celanese	105	95	100	88	102	104	94	92	11	8	2.8	2.7
Dow Chemical	530	510	508	492	460	404	314	269	4	4	4.4	4.5
Du Pont ^b	1100	1000	945	875	775	647	591	509	10	14	6.2	5.7
Ethyl	42	42	39	39	39	37	34	29	0	8	2.4	2.2
W. R. Grace	90	80	82	71	62	55	45	42	13	13	1.2	1.1
Hercules ^c	79	70	66	74	74	65	57	50	13	-5	2.7	2.8
Monsanto ^d	450	385	385	290	264	233	208	161	17	33	5.3	4.6
Olin ^d	53	50	55	51	47	39	31	26	6	-2	2.4	2.6
PPG Industries	na	na	125	127	127	119	103	83	na	na	na	3.4
Rohm & Haas	120	109	100	100	92	77	67	54	10	9	5.1	5.3
Stauffer Chemical ^e	68	66	66	63	57	49	44	35	2	5	4.3	4.8
Union Carbide	275	255	250	245	240	207	166	161	8	4	2.7	2.7
TOTAL	\$3218^e	\$2946^e	\$2998	\$2643^a	\$2566	\$2240	\$1932	\$1665			4.1%	4.0%
ANNUAL CHANGE	9%	11%	8%	8%	15%	16%	16%	13%				

a Figures are for fiscal year ending Sept. 30. b All figures exclude Conoco. c Figures up to and including most of 1983 include polypropylene-related R&D. Since November 1983 polypropylene R&D has been handled by Himont joint venture. d Figure for 1985 is preliminary estimate. e Excluding PPG Industries. na = not available.

pany spent some 5.3% of sales on research, a sure sign of R&D dynamism for a firm that never devoted more than 3% of sales to research throughout the 1970s.

R&D expenditures by Dow, still the second biggest chemical research spender, remain well above the industry composite at 4.4% of sales. So do those by American Cyanamid, which expends some 6.2% of sales on R&D—more than half on medical and agricultural research.

Both firms, however, have scheduled just 4% increases in their research budgets for 1985.

Several smaller firms have planned large percentage increases in their R&D budgets for 1985. Air Products, for instance, will boost its spending 16% to \$51 million in fiscal 1985 (which ends Sept. 30). The company says that about two thirds of those expenditures will fund new technology initiatives such as core business-related research in ad-

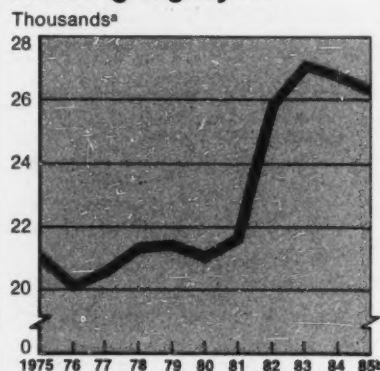
vanced air separation technologies, polymer chemistry, amine chemistry, catalysis and inorganic chemistry, diversification-related research in electronics, advanced ceramics, industrial microbiology, and non-cryogenic separations. The remaining third will be spent for existing technologies in core businesses.

Hercules has planned a 13% increase in 1985 to some \$79 million. The company's level of R&D spending dipped in 1984 to \$70 million from \$74 million in 1983, but the decline was more a function of the assignment of Hercules' polypropylene activities to its Himont joint venture with Montedison in November 1983 than a reflection of decreased research emphasis.

W. R. Grace, having boosted its involvement in biotechnology last year, is adding another 13% to its annual R&D budget, and is now planning to spend \$90 million on research in 1985. Still, it continues to devote the smallest share of its sales—just 1.2%—to R&D spending of any of the 14 chemical firms.

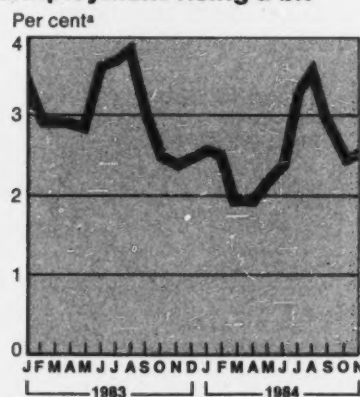
Rohm & Haas, traditionally a heavy research spender, will boost its 1985 R&D budget 10% to \$120 million. The largest part of the company's research spending goes for polymer research, with work in agricultural and electronic chemicals also getting a lot of attention. □

Professional R&D staffs declining slightly...



a Full-time equivalent R&D scientists and engineers in basic chemical industry at beginning of year. b Estimate. Sources: National Science Foundation, C&EN surveys

... and technical professional unemployment rising a bit



a Unemployment rate for professional specialty employees, including engineers, mathematical and computer scientists, natural scientists, health diagnosing occupations, health assessment and treating occupations, teachers, lawyers, and judges. Not seasonally adjusted. Source: Bureau of Labor Statistics

Carbide chairman Anderson
explains post-Bhopal strategy
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Industrial surfactants

A hidden but crucial role
from leather tanning to oil fields

Page 23

News of the Week

■ In India, reports of Bhopal deaths far exceeding 2000 persist; in U.S., developments related to the accident accelerate in government and industry. **Page 4**

■ Rudolph Marcus of California Institute of Technology awarded Wolf Prize in chemistry. **Page 6**

Business

Union Carbide chairman Warren Anderson discusses effects of the Bhopal tragedy on the firm and on industry worldwide. **Page 9**

Government

Cleanup of selenium-polluted reservoir in California halted while state and federal officials wrangle over approach. **Page 18**

Science

Size of small clusters of transition metal atoms affects reactions occurring on the clusters' surface, Rice chemists find. **Page 51**

Yale researchers develop paramagnetic shift reagents that bind to Lewis acids as well as to Lewis bases. **Page 52**

Technology

Japanese scientists devise voltametric detection system that will measure concentration of chloride ion in fresh concrete. **Page 53**

National Bureau of Standards sets up two-tiered system to verify and document accuracy of radiation measurements. **Page 53**

ACS News

Official reports from December meeting of ACS Board of Directors include detailed reports of committees. **Page 56**

ACS members strongly support activities to inform the public on chemicals and the environment, boost science in schools. **Page 57**

Cover: Leather processing, shown here in Argentina, is one of myriad outlets for industrial surfactants. Photo courtesy of BASF America

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Product Report

Industrial surfactants producers see substantial growth ahead in areas such as oil fields, fibers, pesticides, and slurries. **Page 23**



Industrial Surfactants Set for Strong Growth



BASF Wyandotte photo

Oil fields are biggest market for industrial surfactants used for froths, well stimulants, demulsifiers, enhanced recovery

Patricia L. Layman, C&EN London

Where there is foamy lather, there usually is a surfactant. But does it follow that if there are no bubbles and foam, there are no surfactants? Not with industrial surfactants, where some specifications for the compounds even require foam suppression. For industrial surfactants, instead, the role is that of a usually hidden—but crucial—facilitator.

For such surfactants, the markets are quite different from those of their household-detergent brethren, used in commodity quantities in a handful of well-defined and well-tracked end uses, made by a relatively small number of large chemical suppliers. For industrial surfactants, instead, there is a plethora of ill-defined, fragmented markets, which use small quantities of surfactants—sometimes

down to the parts-per-million level—and supplied by a host of companies ranging from the giants to the very small specialty outfits.

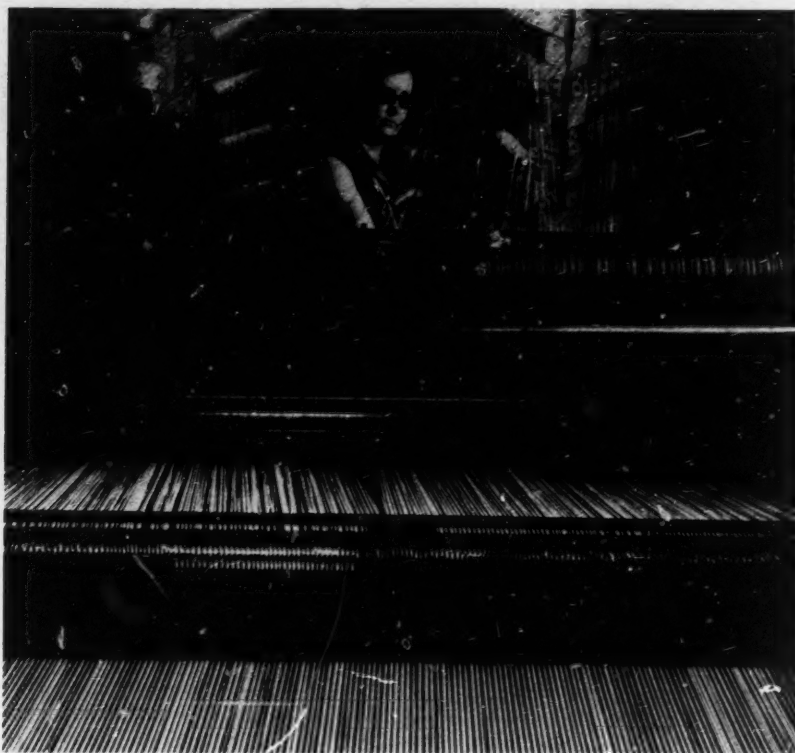
Industrial surfactants find their way into a vast number of industries. In fact, as one marketer puts it, there is no industry that doesn't use surfactants; they all do, to some extent. The industries can be as prosaic as asphalt manufacturing or as exotic as building antisoiling properties into carpet fibers. They can be as large as petroleum production and additives, which are a nearly 800 million lb-per-year market in the U.S., to the smaller, such as the 50 million or so lb-per-year market for surfactants used in the leather and fur processing industries.

Although a large percentage of the industrial surfactant field consists of lower-priced commodity surfactants,

such as the lignosulfonates, which help bring down the overall value of the business, a number of specialty surfactants still are capable of earning respectable prices and profits.

In fact, the industrial surfactants business has a healthier growth rate in sight than does its counterpart household-detergent surfactants industry. That industry closely tracks population growth and the growth in gross national product, and probably will grow 2 to 3% per year over the next few years. Demand for industrial surfactants, on the other hand, may well grow 4 to 5% per year over the same period, with some segments shooting up 10% per year or more.

North American industrial markets consumed some 3.6 billion lb or so of surfactants in 1983, according to Colin A. Houston, president of the



In production of synthetic fibers, surfactants are used to provide antistatic properties as well as processing lubricity

consulting company Colin A. Houston & Associates, who in 1983 completed a survey on surfactants in industrial applications in the U.S., Canada, and Mexico. At that time, he predicted growth of only 2.9% per year to reach annual consumption of 4.4 billion lb in 1990.

The relatively mature U.S. and Canadian markets were slated for a 2.5%-per-year growth. Mexican markets, still developing, would grow at more than 10% per year, Houston predicted. (Those figures all include institutional and industrial cleaners—the so-called “I and I” market for formulated janitorial, sanitation, and similar cleaners—which this report does not cover. The “I and I” business is generally reckoned at about 15 to 16% of total industrial surfactant consumption.)

With the North American market for industrial surfactants well on its way to more than 4 billion lb by 1990, Houston has turned his eyes to Western Europe, looking at the counterpart market. In many ways, market research in Europe is more difficult than in the U.S. or even in the North American continent. One

of the first decisions, for example, is which countries will be included, just the European Economic Community countries, or all non-Eastern bloc countries? For a survey on industrial surfactants, will the researcher include lignosulfonates, the predominant U.S. material? If so, the figures won't agree with those of West German market researchers, who rather haughtily dismiss lignosulfonates from the ranks of true surfactants. Similar other discrepancies dog the studious market researcher.

However, from data from Shell Chemical, presented at the world Surfactants Congress in Munich last May, it would appear that Western European consumption of industrial surfactants is about half that of the U.S.—576,000 metric tons per year, as compared with about 1.26 million metric tons in the U.S. estimated for this year.

In part, consumption is larger in the U.S. because a number of markets using industrial surfactants in the U.S. are more highly developed than in Europe. For example, mining as an end use for surfactants is more highly developed in the U.S., if for no other

reason than that more mining is done in the U.S. than in Europe. And in the petroleum industry, nearly all U.S. oil companies are highly sophisticated when it comes to using surfactants in oil production, one European surfactants marketer says. In Europe, however, only two are: Royal/Dutch Shell, the Anglo-Dutch company; and British Petroleum. The others do little R&D into surfactant applications.

And R&D is what counts in the industrial surfactants business. There are a few industrial end uses in which surfactants are used for their traditional laundering and washing characteristics—textile processing, for example, and leather and fur processing. More commonly, however, surfactants function as processing chemicals, additives in the industrial process itself.

As such, they are aids to saving energy, for example, the activation energy of polymerization by micelle formation; the milling energy for pigments by dispersion of the particles and prevention of their re-agglomeration; the wetting and spreading energy of reducing the surface tension of coatings. Moreover, they save on the dissipation energy for electrical charges of fibers by lowering the electrical resistance of fiber surfaces.

Most of the R&D pertinent to industrial surfactants, then, is aimed at the processes themselves, not surfactants. For a surfactant to be accepted into use, it must fit itself into the process. That usually means surfactants tailor-made or adapted to solve the specific need in the process, or special blends of surfactants that can do the job. Few companies can afford to become expert in all the end-use markets that industrial surfactants are sold into, a number that one marketer says seems on hectic days in particular to be in the thousands. Realistically, companies have to put some limit on their efforts.

In some cases, particularly the larger, multichemical-product-line companies, the strategy is to know thoroughly the properties of the surfactants offered. In many cases, that suffices for a company's technical-service and R&D people to work with customers to design products they need. In other cases, though, the

Product Report

company will have experts on the markets themselves, working to develop new applications.

Even within one end-use market, different surfactants may be required. For example, within the textile processing industry, there will be a need for phosphate esters for lubrication, blends of surfactants for dye-carrier emulsification, special surfactants for mercerization, and still others for aiding dye penetration.

Compounding a supplier's problem is that when surfactants are crucial enough to a process and if the buyer is large enough, the buyer may well have captive surfactant operations. It's not unusual in the textile industry, for example, for large textile producers to have captive surfactant production.

That helps point out the two-tiered nature of the markets that industrial surfactants are sold into. Especially in Western Europe but also in the U.S., large customers—for instance, in plastics and paint processing or agricultural chemicals—are also surfactant producers. This is where the R&D is done, in the big companies, says one surfactants producer. The large companies develop their own systems and processes, using the surfactants they already sell. That makes it difficult for new suppliers to get in. Besides, if processors change one product in the system, they must



Surfactants incorporated into lube-oil additives give detergency and provide sludge dispersion for motor vehicle lubricants

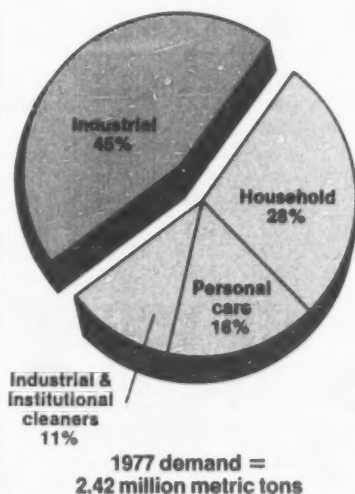
often change the entire system, resulting in another hurdle for merchant suppliers.

On the other hand, smaller companies don't have such extensive R&D backup in-house, so they rely on the surfactant supplier. Reports one business development specialist, "You can be selling somebody a highly specialized surfactant for their process, and the guy at the plant will just call up and say, 'Send some more soap.'" Such customers couldn't care less about what the surfactant is: what its chemistry is, how it works, and so on. All that

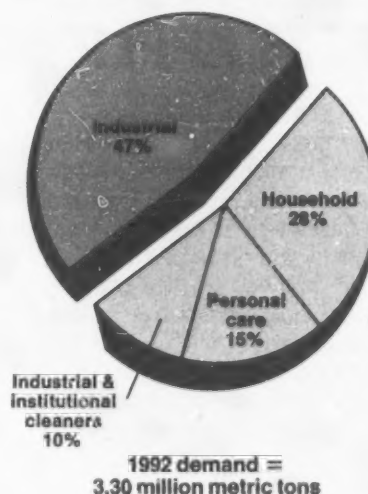
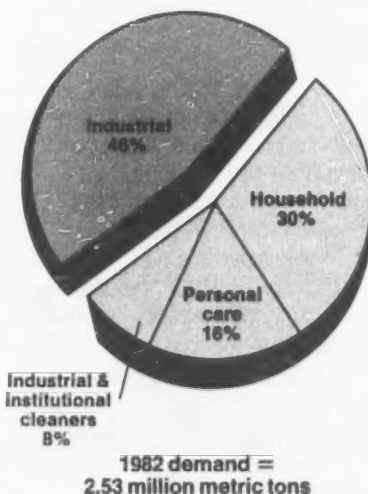
matters is whether it works to the specifications in the process.

In many of these areas, then, selling to the industrial surfactants industry becomes the task of selling to the classic chemical specialty business. Not only must suppliers know what the customer needs, they must know how the customer works with a process and what is important to the customer in the process. Suppliers must, therefore, be willing to work with their customers to find out how they work, then go back to the lab to do the same kind of testing, so they can come back to demonstrate

Industrial surfactants will slowly increase their share of U.S. surfactant market by 1992



Source: Shell Chemical



the same kind of functionality the customers need.

That is also one of the major differences between selling to the industrial surfactant users and selling to the household detergent industry. As expert and smart as surfactant suppliers can be, for example, there is little about surfactant chemistry and functioning that they can tell customers like Procter & Gamble, Colgate-Palmolive, Henkel, or Kao Soap, who all live and breathe detergents.

Dealing with those kinds of customers, it is sales representative to purchasing agent. In the industrial surfactants business, however, far more commonly, it is chemist to chemist, or engineer to engineer. At that level, a chemist can better evaluate, require a bit of fine-tuning, a bit more work, to solve the customer's specific problem.

Such problem solving often can involve confidentiality, and that places the burden of integrity on a supplier. "If the customer defines his problem and we solve it, we can't take this information to other customers," says one marketer. "It's his secret. That means we have to be careful about our commitments. Is that sale large enough to make up for others that we would lose in the same field?"

Again, that is a major difference

between industrial and household-detergent surfactants. Far from having to worry about confidentiality and customers' proprietary knowledge, when suppliers are selling to the household detergent industry, they frequently don't know precisely how their material is being used.

That's not the kind of marketing that pleases industrial-surfactant suppliers, however. It's much more profitable to seek out new areas in which supplier expertise can be a valuable addition to the business. The trick is merely to figure out which market areas those are.

One method to do that is formal establishment of a business development unit, charged with identifying market areas both new and new for the company. Northfield, Ill.-based Stepan Chemical, for example, took that tack as part of a regrouping into business teams several years ago. By 1983 it had its eye on three areas, which have since expanded beyond the pilot-testing stage: surfactant additives for concrete admixtures, surfactant-based foams for oil field service companies, and wetting and foaming agents for use in dust and particulate suppression.

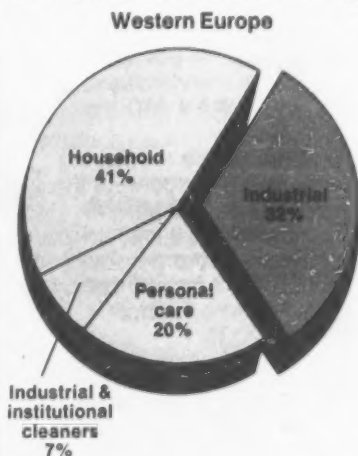
Akzo Chemie wound up on a slightly different tack, almost by accident. The Dutch chemical company had specialized in surfactants for cosmetics almost exclusively, but

eventually identified as part of its in-house expertise the technology to formulate a metal cleaner for low-temperature degreasing. That was a departure from previous practice, and the company now is marketing the product as a finished formulation, rather than merely a surfactant for someone else to formulate with. It opened up a new marketing area.

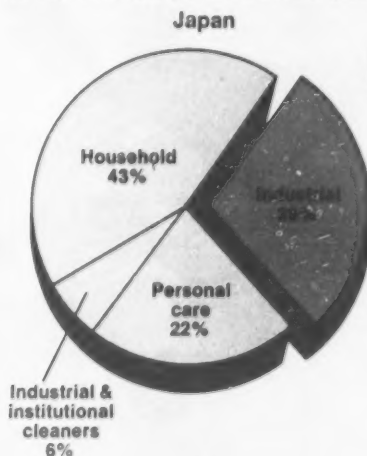
Surfactant suppliers historically have been careful to avoid entering markets also supplied by their customers, to avoid conflicts. But for Akzo, metal degreasing was a far cry from the personal-care field it had been supplying, so the company felt it would be stepping on no toes (at least of its own customers) by entering the business.

The point eventually reached, however, is the need for companies to work out special uses for special customers, as one marketer puts it. A company has to take on such an effort if it wants to find the growth and profits that bypass commodities. No longer can suppliers who are serious about the business afford to rest on their laurels. The business too quickly becomes full of me-too surfactants competing on price, not performance. In as little as two years, a proper specialty surfactant can have multiple suppliers, selling on price, one estimate goes. That leads to price deterioration, and to increasing

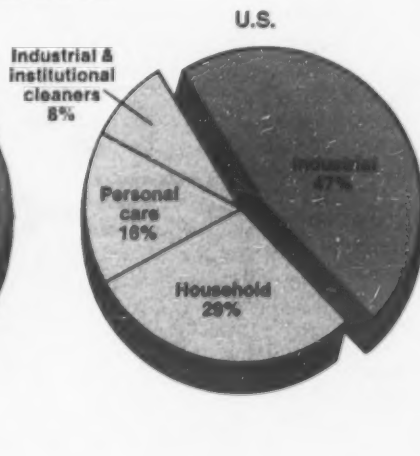
Industrial markets take big share of western surfactant production



1995 production =
1.78 million to 1.8 million metric tons



1985 production =
650,000 to 660,000 metric tons



1985 production =
2.65 million to 2.7 million metric tons

Sources: Shell Chemical, C&EN estimates

BASF Wyandotte photo



In pesticides, surfactants dilute and disperse active compounds and wet leaves of plants to achieve best penetration of pesticide

pressures for controlling production and distribution costs, and about that time, suppliers are selling commodities.

It doesn't always take fancy R&D to do well with industrial surfactants. Sometimes companies find that, by controlling their own processing conditions, they can improve batch-to-batch responsibility, and earn a higher price for better-quality surfactants. Then, it becomes a matter of convincing the customer that better quality is worth the price. Marketers joke a bit about a "convincibility" index, of which end-use industries go for performance, and which stick on price.

The key seems to be how integral a part in the process the surfactant plays. The more crucial the surfactant, and the better-quality end product the customer can produce, the more that customer is apt to be convinced that the higher price is worth it; the volume used surprisingly doesn't always count.

Petroleum-industry surfactants are far and away the largest end-use market in this business, both for producing petroleum and for incorporating into oil formulations—oil additive packages, lubes and greases, and so on. At 700 million to 800 million lb per year in the U.S., such surfactants are just part of a worldwide oil-field chemicals-and-service business worth \$9.3 billion in 1982, according to consultant Houston. Most of that is in North America, but

non-North American business was 37% of the total, and growing in importance—an indication that surfactants for oil-field use will be growing, as well.

For several years, the end use of enhanced oil recovery has held out to surfactant suppliers the promise of vast, untold sales. Forecasters' crystal balls frequently took on the colors of fairy-tale riches. And most industry observers agree that if and when the market takes off, it will be wish fulfillment for the industry.

But for the time being, crude oil prices are down, and few producers have projects coming up. Stepan, for one, noted in its annual report for 1983 that the "significant declines in

sales and earnings for petroleum sulfonates from our enhanced oil recovery business were caused by the completion of two major contracts and the lower level of crude oil prices."

However, consultant Houston sees production and consumption in the world oil industry starting to increase and by the end of next year demand balancing production.

Enhanced—or tertiary—recovery isn't strictly surfactant, suppliers concede. They must compete with carbon dioxide technology, for example. And they must live with predictions such as those of Shell UK, which, speaking about North Sea oil, recently was quoted in British newspapers as saying that a barrel of oil produced by enhanced recovery methods could be up to 100 times more expensive than normal.

However, according to Donald E. Haupt, manager of the detergents department at Shell Chemical, at the Munich conference in May, "Although the recently favorable crude oil supply situation probably has led to a delay in the time when [enhanced oil recovery] will be employed on a large scale, the real questions are 'when' and 'what kind' of effort will be needed—not 'whether.'"

In the meantime, surfactant suppliers concentrate on their role as an adjunct to the service companies, which take surfactants and formulate them into whatever various compounds they use. Typical uses are

Suppliers range from giants to small specialty firms

With the household detergent industry, such large quantities of surfactants are demanded that, by and large, it's a big-boys' business. Major suppliers of detergent intermediates include such chemical giants as Vista Chemical, Shell Chemical, Monsanto, Chimica Augusta, Petresca, and Ethyl (C&EN, Jan. 23, 1984, page 17).

For supplying industrial surfactants, the roster changes dramatically. To some extent, giants such as Shell and Chimica Augusta do supply the business. But even as they are tracking markets, those large producers manage to give the impression that they feel frustrated by the small size of the markets.

Instead, the major suppliers are companies such as Rohm & Haas, Wilco Chemical, Stepan Chemical, GAF, DeSoto, and—one of the few giants keenly supplying the industry—Union Carbide. Henkel, BASF, Akzo Chemie, and Hoechst are active suppliers on both sides of the Atlantic. Many other companies are in the business, such as Onyx, Lonza, Pilot Chemical, and Mona Industries. Du Pont and 3M are particularly active with their specialty fluorosurfactants; American Cyanamid has strength in supplying the mining industry. Jordan Chemical started out as a supplier to the textile industry, almost exclusively, and has since branched out.

high-density froths to bring up drilling matter and water from formations, surfactants to stimulate wells, and demulsifiers to break contaminant water out of the oil as it is brought up before it is refined. Secondary recovery, using water flooding, also offers markets for surfactants, which provide corrosion inhibition and surface wetting to allow water to penetrate the formation.

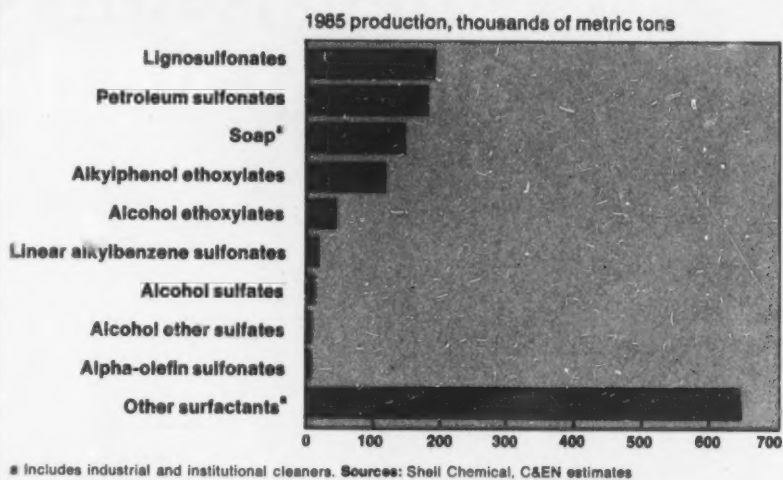
Surfactants are incorporated into petroleum compounds such as lube-oil additive packages. They give detergency and provide sludge dispersion not just for lubricants for motor vehicles but for other oils, such as cutting oils, and similar other processing oils and lubricants.

Emulsion polymerization is probably the second largest market for industrial surfactants. Emulsions bound for paints, paper coatings, industrial coatings, and emulsified monomers for polymerization all depend upon the surfactants in the formulation. In fact, according to industry marketers, this is one of the most sophisticated fields they sell into, in terms of the quality and performance demanded of surfactants. The surfactants become an integral part of the formulation, and at least one marketer becomes rather indignant at the term "processing aids." "Emulsifiers are not processing aids, they are additives for the product," he argues.

The point is to put into water some materials that are insoluble in water. Monomers can be solubilized, so they can polymerize in an aqueous solution to form latexes for various paints, coatings, and binders. The surfactants used in this application are largely anionics, although some nonionics are used. And it is in the emulsion-dispersion of synthetic rubber that soap finds one of its major industrial applications.

Surfactants now are used at concentrations of about $4\% \pm 1.5\%$. There is a trend toward using less material, because customers fear that surfactants can impart some undesirable properties to latex mixes, such as adversely affecting the stability of the latex, for example. And there is significant research being done on building surfactant functionality into a monomer—no surfactant per se,

Lignosulfonates, petroleum sulfonates dominate U.S. industrial surfactant output



but formulating the monomer with the functionality built into the molecule so the resulting polymer will have surfactant properties.

According to some marketers, the surfactants that a processor chooses can be the key ingredient in the quality of the emulsion. "The monomer and water for the system are both very pure," says one marketer, "so the surfactant becomes important for the quality. Customers push us to make better-quality surfactants, and they give us a premium for this higher quality." This drive, he adds, has been especially strong in the past three or four years.

Surfactants for asphalt and cement are a well-established old market, with a surprising amount of R&D and new-product activity bubbling up. On the cement/concrete side, surfactants serve as air-entraining agents to help control the air-bubble size and spacings. Surfactants also help make workable concrete more flowable, easier to use. (They already have assisted in production of the mix, as grinding aids.)

As plasticizers, the surfactants can reduce the amount of water needed in the concrete formulation, yet still retain the fluidity needed, and, at the same time, have greater strength. Typical use rate is somewhere in a range of 1 oz to 1 lb per 100 lb of cement in the formula.

A casual observer might think that for such a commodity-type end use

the demand would be for lowest-possible-cost surfactants. But suppliers say there has been a demand lately for improvements in concrete. "When a formulator is using a surfactant to gain fluidity, it can save on labor costs, which can more than [offset] surfactant costs," reports one supplier. "There are many more costs than just raw materials costs, which actually tend to fade in importance."

Surfactants also are competing for the developing market for cellular concrete, used for its barrier properties against, for example, heat or sound. Its lightweight, cellular structure could be obtained by using blowing agents, or the producer could use surfactants for producing the foam incorporated into the structure.

Surfactants used for concrete can be anionic or cationic types; the selection frequently depends upon the nature of the aggregate in the mix. Limestone aggregate, for example, takes anionics; granitic aggregate, cationics.

Cationic amines, though, are the primary beneficiary for the latest revolution in asphaltic emulsions. As environmental pressures nudge users away from solvent-carried asphalt, which must be heated for use during which time solvent vapors are given off, cold-setting asphalts are gaining in popularity. That's especially true for asphalt repairs. The

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cold-setting formulations allow relatively quick and easy application. This, then, is one of the "respectably" growing markets for industrial surfactants identified for the remainder of the 1980s. When added to the market for "superplasticizers" in concrete that consultant Houston picks out specifically as growing faster than all other plasticizers during the same period, the prosaic world of cement and concrete takes on a more glamorous aura.

Textile processing and fiber manufacture are two completely different markets, suppliers say, when it comes to sophistication of demand and need for surfactants. The textile side tends to be very commodity oriented, using heavily from the commodity side of alkylphenol ethoxylates and alcohol ethoxylates. These materials have been used for years, are low in price, and are not very specialized.

Their major function is to remove processing oils, scour the textiles, and so on—more or less classical surfactant/detergent functioning. Newer textile technology, however, is put-

ting increasing demands on the surfactants used. For example, during high-temperature scouring, suppliers say, nonionics might deposit onto the fibers being scoured, exhausting the surfactant in the wash bath. Anionics, on the other hand, rinse freely, and last longer in the bath concentration.

On the other hand, high-speed processing increases the need for good antistatic properties, so textile makers would prefer nonionic surfactants, which can contribute those properties.

Much more specialty oriented is the fibers side of the industry, or perhaps chemically oriented is a better description. Compared with textile manufacturers, who don't necessarily have to worry about the chemistry of a surfactant but only that it will work, fiber makers are more demanding of their surfactants. That's not surprising, however, given the limited number of fiber makers and their chemical background. It is also, suppliers grumble, far more secretive than textile manufacturing.

Antistatic compounds are especially important—typically phosphate esters, with a few others for selected applications such as fine-denier nylons.

And processing lubricity is another important function. BASF Wyandotte, for one, is busy developing the market for its block copolymers—ethylene oxide-propylene oxide copolymers—for this application because, the company says, these special nonionics function well at the high speeds in fiber production. The processes are so fast, they generate temperatures occasionally reaching 200 °C. Most of the older-generation surfactants, under those temperatures, would burn off the fibers with a smoky discharge, leaving a gummy residue. The residue could adversely affect the machinery, causing fiber breakage and downtime. The block copolymers burn off cleanly, with no residue.

Depending upon the fiber and upon how much lubricity is needed, from 0.5 to 3.0% of finish solution is added onto the fiber. The solution

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Product Report

Petroleum uses lead U.S. industrial surfactant market

Millions of lb per year*

Petroleum production, additives	750
Plastics processing	313
Asphalt/cement	300
Textiles processing	250
Paints	150
Pulp, paper processing	125
Agricultural chemicals	100

* On a 100%-active basis. Source: Colin A. Houston & Associates

typically contains 30% active surfactant compound.

Performance, suppliers add, is all-important in this application. "The fibers industry is very manufacturing-driven," says one. "The emphasis is on getting the material out. If they find something that works, they'll stay with it." But conversely, adds another supplier, to introduce a new surfactant can take years. There is so much risk for the fibers maker in modifying a process that already works well.

Agricultural chemicals are an end use of growing importance for industrial surfactants. They play two functions: to dilute and disperse pesticide compounds, and to wet the leaves of the plants, for achieving the best penetration of pesticide, which can include insecticides, herbicides, and fungicides.

There are many different forms of pesticides, of course—liquids, powders, and so on. Some contain water and some solvents, but the current trends seem to be taking the industry in the direction of aqueous systems. That's a problem when many of the active compounds in pesticides are not soluble in water.

Pesticides are being made in more and more concentrated forms by manufacturers—too concentrated to use as is. Blends of anionics and nonionics, or single-class surfactants come into play, to emulsify the dilutions. That way, when the dilutions are added to water, they will mix readily and can produce a homogeneous spray. Surfactants are typically 5 to 10% by weight of a pesticide product; suppliers sell directly to the manufacturer, who formulates various strengths for the market.

NEW INTEROX BLEACH SYSTEMS TO MEET CHANGING U.S. NEEDS

Interox today is the largest supplier of peroxygen chemicals to the international detergent industry. Basic in hydrogen peroxide manufacture, Interox produces the widest range of peroxygen derivatives including sodium perborates and percarbonates, persulfates, organic peroxides, organic and inorganic peroxyacids and their salts, and inorganic peroxides. This broad product technology base allows faster upgrading of existing products and the development of new materials to meet the customer's changing needs.

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- Interox America built a new Texas facility which employed an advanced, proprietary fluid bed-technique to make sodium percarbonate. The end product has the physical and chemical property combination required for the fabric-safe-bleach concentrate market.

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temperature highly stable peroxyacid, Interox H48. It is the first of a new generation of safer organic peroxy bleaches for the detergent industry.

- Peroxyacid bleaching systems formed in situ from an activated persalt are an alternative to preformed peroxyacids added to a formulation. Already used in Europe, activated persalts are good low-temperature bleaches. The rate at which the peroxyacid is delivered to the wash, and the efficiency of the peracid generated, is more critical under U.S. conditions. Interox has invented a number of developmental activators and activated bleach systems which can release the peracid, in situ, extremely rapidly.

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Product Report

Similarly, surfactants assist the production of water-dispersible granules, which carry high amounts of pesticide active compounds into the package. The water-dispersible granules help eliminate dusting—no dusty particles are floating around to pose health problems to factory workers or consumers. For these, surfactants are 2 to 4% by weight of the system.

Nonionics assist with emulsion and dispersion; anionics also improve surface wettability and formulation stability. Which surfactants are used depends on which active compounds, in what form, and at what concentration are involved. Suppliers say this is one of the most highly tailored end-use markets they sell to.

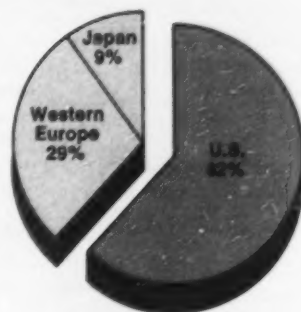
Other end-use applications are smaller, but important nonetheless. They include:

- Metal treatment, for pre-, during, and post-whatever operations are being carried out on the metal substrate. The surfactants solubilize the soils present on the metal and disperse them as they are removed. Among the performance-affecting factors are the pH of the bath, the water hardness, the variety of soil types, and whether foam is desired.

- Defoamers, for wherever foam is not desired. Most of the market presently is made up of specialty silicone defoaming agents, not surfactants. But marketers think there is a small but healthy demand for defoamers that also happen to have surfactant functionality. The formulating might be somewhat easier for a system that also has other surfactants. Use could range from 0.1 to 10%—not surprising given the literally thousands of different applications and variations requiring defoamers.

- Mining, for ore flotation and mineral beneficiation. Minerals adsorb on surfactant froth bubbles, to collect at the top of a bath. They can then be collected as an enriched yield from what normally would have been obtained. Conversely, proper selection of surfactants also can be used to suppress minerals one doesn't want to float. The surfactants are highly tailored, specific for each mineral, although some formulations will work generally on ore groups.

U.S. uses more surfactants than Europe and Japan



Total 1985 demand =
2.03 million metric tons*

* Industrial surfactants.
Sources: Shell Chemical, C&EN estimates

For example, xanthates would be used to beneficiate sulfide ores. Cationics, on the other hand, would be used for nonmetallic ores such as potash and silica. The use range depends on the mineral. For example, for copper, which runs 0.6 to 0.8% of the ore, a surfactant might be included at 0.02 to 0.05 lb per ton of ore. For nonmetallics, which frequently make up 50 to 75% of the ore, surfactants would be used at 1 to 2 lb per ton of ore. The U.S. market for mining/ore flotation surfactants at present is depressed, reflecting the state of health of the industry itself. However, marketers say that it is highly active in developing countries, and that this application for surfactants definitely is growing.

- Dust control, for suppressing particulate, airborne pollution. Catching the sometimes ill wind of governmental regulations, suppliers of industrial surfactants are working to develop systems to suppress dust and other airborne particulate pollution in the workplace. The Occupational Safety & Health Administration is encouraging such dust suppression, so there is a market opening up. How long it will continue, or how fast it will grow will depend upon governmental regulations, speed of decisions, and strictness of enforcement, of course. But for the time being, it offers an attractive market, with at least one company saying that its sales into this segment tripled from 1983 to 1984.

- Paper processing, primarily

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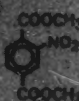
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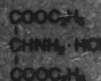
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Product Report

deinking surfactants, and desizers. Both tend to be commodity applications, not highly sophisticated markets.

- Water treatment, primarily for corrosion inhibition. Increasingly important for cooling water systems wherever large quantities of water are used—for example, in oil-field chemicals, the pulp and paper industry, and the chemical industry—these surfactants are particularly fast-growing, says consultant Houston. Typically used are cationics and polyacrylamides.

- Wood preservation, another specialty market for cationic surfactants, which involves temporary or low-level protection of wood. Suppliers are quick to concede that the surfactants are not so effective as materials such as pentachlorophenol, and would not work for difficult tasks, such as total wood impregnation. But they point out that their surfactants are relatively "innocent" in the environment, much more so than the chlorinated organics. They are being used increasingly where they are able to meet the demands: for example, protecting wood when it is being transported from mill to user.

- Antisoiling agents for carpets. These are generally fluorosurfactants, which Houston pegs as showing "extraordinary growth," adding that this "high-unit-price market is expected to reach \$40 million by 1985," in North America.

- Coal slurries, a potentially important end use slowly evolving in the U.S. Surfactant technology developed for coal slurry transport also could be modified for transport of other materials. The market is expected to increase dramatically over the next few years. One optimistic prediction holds that the market may reach 200 million lb by 1990.

Regardless of whether the coal slurry market develops, it is just one of many new areas for industrial surfactants that suppliers are investigating. As one marketer puts it, "We are all looking for new and better products, with shifts from one product to another, for new and better end uses."

Some suppliers firmly believe that industrial markets offer the opportunity for providing specialty prod-

ucts that can offer better profits than from household-detergent sales. The major emphasis is on product development, working with people who have problems. That means committed technical service and backup R&D.

The market is fragmented, no doubt, but at least one supplier believes that that is an advantage. "We want to make special blends of surfactants—specific combinations—to do a specific job. We've a lot of products and a lot of customers."

The industrial surfactants business, in fact, may be fortunate to not have the large, concentrated customers that the household detergent business has. "If you lose one big customer, you're out of business, there," argues one supplier. Even if the several-drumload customer must be serviced by distributors, with backup provided by the surfactant supplier, the opportunities for developing those small customers to larger ones are what give the industrial surfactants business the excitement of growth and profits. □

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Acid Rain in Europe

Tree damage sparks action

Page 12

News of the Week

■ Many U.S. chemical firms had earnings declines in the fourth quarter. **Page 6**

■ Planned construction of Army lab to test defenses against biological weapons delayed by lawsuit. **Page 7**

■ Monsanto will make available to the public data on substances it makes or uses and what hazards they pose. **Page 7**

■ Study indicates OSHA limits on worker exposure to butadiene may be inadequate. **Page 7**

■ EPA inspection report on Carbide's Institute plant reveals only minor violations. **Page 8**

Cover: Damaged trees in West German forest. Photo copyright: Artreference, Frankfurt

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Business

Chemical stocks didn't do well in second-half 1984; stagnation of prices, poor foreign trade were chief causes. **Page 20**

U.S. consumption of engineering resins in 1984 was a whopping 18% higher than in 1983 as auto, housing markets rose. **Page 23**

International

Members of the Indian scientific community and the press criticize the government for downplaying the Bhopal tragedy. **Page 24**

Government

Technical alternatives to protect industry from disruptions in supply of critical metals assessed in OTA report. **Page 29**

Education

Student Pugwash international conference invites college students to discuss ethics, social aspects of science and technology. **Page 35**

Science

Plant described in 16th century monograph on Mexican natural history found to contain intensely sweet substance. **Page 37**



News Focus

Reports of increasing damage to trees, lakes, and monuments lead West and East European countries to agree to lower emissions of sulfur dioxide. **Page 12**

Chemical & Engineering News

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LETTERS

Early history about methylene

SIR: The recent article (C&EN, Nov. 26, 1984, page 30) discussing the resolution of questions concerning the properties of methylene omitted some interesting early history of work on this substance.

G. A. Gallup [*J. Chem. Phys.*, **16**, 716 (1957)] was the first to give a theoretical treatment that predicted methylene to be in a bent triplet ground state. This result ran counter to the view commonly held at the time that the Jahn-Teller effect would force methylene to be sharply bent but with a singlet ground state. The calculation used what today would be called an extended Hückel treatment with, however, some additional semiempirical information obtained from excited states of the carbon atom that is not typical of that approach.

The spectroscopy of methylene at that time was still under investigation, but the available results seemed to rule out a sharply bent structure [Herzberg, *Rev. Mod. Phys.*, **14**, 195 (1942)].

Gas-phase kinetic studies by W. A. Noyes Jr. suggested that methylene might have a ground, or very low-lying triplet state. This was reported in an ACS tour lecture given in Nebraska by Noyes, but he never felt sure enough of this conjecture to publish it. Gallup was led to his investigation by this talk.

Craig J. Eckhardt

Professor of Chemistry

University of Nebraska, Lincoln

Credit to Bassow and ACS staff

SIR: A recent article (C&EN, Dec. 24, 1984, page 32) reported an award to ACS by President Reagan's Citation Program for Private Sector Initiatives. The ACS initiative was to make technical personnel and other resources in chemically related industry available to secondary schools in the Philadelphia area. Besides Corporation Associates, several groups in the society were essential to the initiation and support of the program, particularly the board of directors and the Committee on Science. Nancy M. Flinn, staff coordinator for Corporation Associates, played a major role in the success of the effort.

Of special importance is recognition of the individual who implemented the program in Philadelphia. Herbert Bassow, an award-winning chemistry teacher from Germantown Friends School, used his sabbatical to this end. He talked with hundreds of teachers and individuals in industry to determine local high school needs and the industrial resources available to fill them. His findings were compiled as the "High School Chemistry Resource

Directory for the Philadelphia/Camden Greater Metropolitan Region" and distributed to the schools in the area.

Bassow and the ACS staff are to be congratulated for the efforts which led to the award.

E. Wasserman, Chairman
Committee on Corporation Associates

Ads in C&EN

SIR: A full-page ad has appeared several times in the "Employment" section of C&EN, sponsored by the department of sciences at Abadan Institute of Technology in Iran.

I cannot understand why C&EN is carrying such ads. The advertiser, the Islamic Republic of Iran, is certainly no friend of the U.S. The hostage crisis several years ago is still fresh in our minds, and the Iranian government almost nightly abuses the U.S. on the news media.

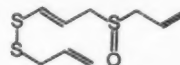
This ad should not have been accepted and those responsible for accepting it should be held accountable. The membership of our organization should not tolerate such poor judgment. Patriotism should not be utilized in political campaigns and on July 4th only; it should be held in very high regard by ACS.

Bernard M. Mitzner
New Hampton, N.Y.

Editor's Note: C&EN policy on the publication of advertisements from foreign employers was discussed at the December 1984 meeting of the C&EN Editorial Board. The consensus of this board was that publication of the advertisement from the Abadan Institute of Technology was not inappropriate and that it would not be practical to develop a blacklist of nations from which such advertisements would not be accepted.

Corrections

- Jan. 7, page 34: The structure of ajoene, as shown, has three (not two) sulfur atoms:



Ajoene

- Jan. 14, page 20: Planned 1985 R&D spending by Union Carbide is \$280 million, not \$275 million.
- Jan. 14, page 44: The date of the State-of-the-Art Symposium on Degradation of Materials to Acid Rain is June 17-19, 1985, not 1984.

European Concern About Acid Rain Is Growing

Motivated in part by reports of widespread and increasing tree damage, many West and East European countries now have pledged to reduce their sulfur dioxide emissions substantially by 1993

Dermot A. O'Sullivan, C&EN London

When West Germans learned a few weeks ago that half of their tree population is showing signs of damage, the news was greeted with a sense of national alarm. Germans have a close and almost spiritual relationship with their forests, which have inspired music and folklore. So the idea of such a large number of trees being under stress is almost inconceivable. Blame for damage is attributed to acid rain.

The data issued by the federal Ministry of Food, Agriculture & Forestry in Bonn appear the more ominous because in 1983, 34% of the country's forested area was identified as being damaged. The previous year, the level was put at a mere 8%.

Admittedly, the sharp rise hasn't occurred in the

short span of three years. Rather, it reflects a better and more widespread system of identification. Neither does it mean that all the trees exhibiting signs of damage are on the verge of death. Trees in less than 3% of the forested area are classed as being "severely sick." But the findings do indicate that something is seriously wrong.

Species showing the most damage are conifers such as fir, pine, and spruce. However, deciduous trees like beech also are affected. One of the most damaged areas is the famed Black Forest, which is largely covered with conifers.

Germans call the tree problem "neuartige waldschäden"—literally, "new kind of forest damage." It is characterized by a yellowing of the needle tips, premature defoliation, and dieback. Because this occurs high up



Severe forest damage in the Erz Gebirge region of western Czechoslovakia from air pollutants from heavy industry



Many Norwegian lakes are picturesque but "dead" because of their high acid content

in the crowns of the trees, few people who stroll through the woods are aware of the damage, comments Manfred Häberle, who is in charge of emissions control and ecology at BASF and also chairs the working party for forest damage at West Germany's Chemical Industry Association. BASF, one of West Germany's big three chemical concerns, is engaged in an ongoing forest research program funded partly by the West German government.

Häberle subscribes to one of several major theories about how air pollutants damage trees. Like a number of other explanations, the theory involves a combination of factors. One of these is the weather. Heavy rains in spring and fall, coupled with incidents of summer drought or unusually high temperatures, adversely affect tree growth, as evidenced by the pattern of tree rings.

In such a weakened state, the reasoning goes, trees are more susceptible to the leaching out of calcium, magnesium, and other essential nutrients from the soil, which, in turn, is promoted by acidification from acid rain. The effect is more pronounced at higher altitudes where the soil tends to be thin. Häberle makes the point that, in relative terms, a pine tree requires the same amount of calcium and magnesium as wheat does for proper growth. He notes that in young trees, yellowing of the needle tips is reversed by applying calcium and magnesium compounds at their base.

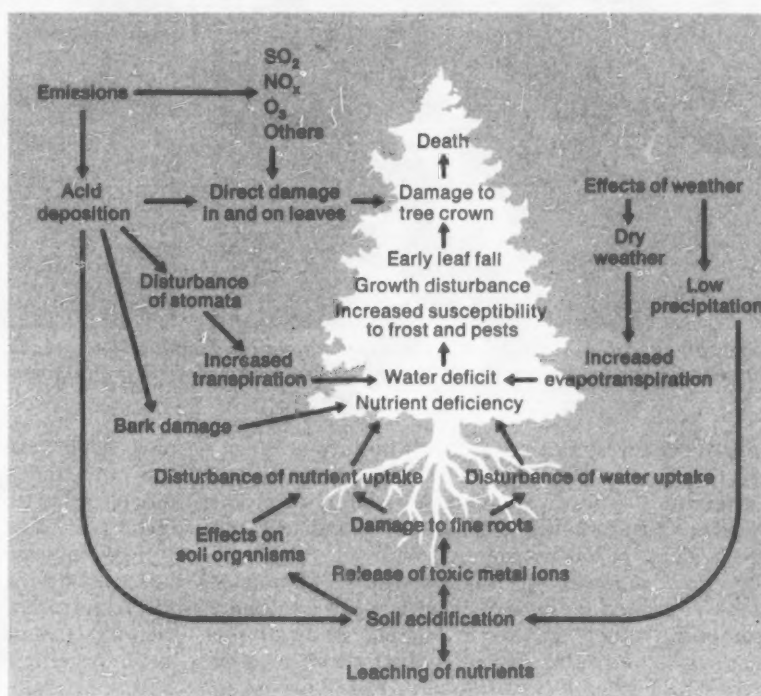
About the time West Germany issued its findings, Sweden's Ministry of Agriculture provided its own set of data on the state of tree damage in the southwestern area of that country. There, too, stress on the conifers appears on the increase. And there, too, acid rain in conjunction with ozone is being named as the culprit.

The two reports, coming so close together, have added to the groundswell of concern throughout Europe on the deleterious effects of acidic components in the atmosphere. And the damage is not limited to trees.

Many historic buildings throughout Europe are bearing the brunt of the attack. An official at Cologne's famed cathedral deplores the fact that by replacing damaged stone, he is overseeing the replacement of a medieval monument.

A report issued last fall by the U.K.'s Parliamentary Environment Committee cites evidence taken from people responsible for the upkeep of St. Paul's Cathedral, Westminster Abbey, and similar structures throughout the U.K. The study quotes architects as-

Air pollutants may damage trees in many ways



Source: Swedish University of Agricultural Sciences

sociated with Lincoln Cathedral, for instance, as saying that the recent acceleration in the deterioration of stonework, particularly that of Romanesque and medieval statuary, is caused by acid rain.

"It is beyond doubt," the report notes, "that acid rain, mainly due to sulfur dioxide emissions, is damaging British buildings, and slowly but surely dissolving away our historic heritage." It recommends that the British government "give urgent and immediate consideration to the cost benefit of preventing the avoidable erosion of both historic and modern buildings."

The acid rain issue is at once simple and extremely complex. Its simplicity rests on the nature of the chemicals involved, essentially sulfur dioxide and sulfates, nitrogen oxides (generally referred to as NO_x), and ozone produced in the atmosphere from nitrogen oxides and hydrocarbons under the influence of ultraviolet light.

That atmospheric acidity adversely affects a variety of ecosystems—from forests in central Europe and Scandinavia to lakes in Scandinavia and Scotland—can hardly be refuted. But the complexity of the subject is reflected in the many theories, some of them conflicting, that have been proposed to explain its mode of action.

Apart from circumstantial evidence, no one really knows precisely the chemical and physiological pathways involved. However, much more is known about the acidification of lakes from acid deposition than is



Deen and Chapter of Lincoln

Photograph of grotesque decorating Lincoln Cathedral in England (left) was taken about 1910, whereas photograph of the same grotesque, taken in 1984, shows effects of atmospheric pollutants on the stonework

known about forest damage from air pollution. Meanwhile, the issue has been pushed into the forefront of the international political arena, spurred by economic, health, and aesthetic considerations, and to some extent by emotive journalism.

The term "acid rain" itself is something of a misnomer. It was coined more than a century ago by Robert Angus Smith when making a detailed study of the atmospheric conditions in the industrialized area of Manchester, England, and the term has since taken hold.

Acid deposition is the more accurate and scientifically preferred term. It is true that sulfur dioxide undergoes oxidation to the trioxide, which in turn converts to sulfuric acid in clouds, fogs, and mists. On the other hand, dry deposition of acidic aerosols and particulates is deemed to be just as damaging, especially as far as the adverse effects on trees and historic buildings are concerned. Moreover, ozone and heavy metals, which contribute to ecosystem damage, are not themselves acidic.

Increase in the level of man-made air pollutants over Europe, and the concomitant rise in the intensity of acid deposition, can be traced back to the industrial revolution. As recently as 30 years or so ago, air quality over heavily industrialized centers had deteriorated to the point where women's hose were known to disintegrate during rainy spells because the level of acidity was high enough to attack the man-made fibers.

Widespread burning of coal both for power generation and domestic heating also led to development of severe episodes of smoke haze combined with weather-related fog. London's "pea-soupers" are legendary. In 1952, some 4000 died, due largely to inhalation of smoke particles on which sulfur dioxide was absorbed. A similar incident there in 1962 brought death to about 800. So bad were conditions that an internationally acclaimed collection of pine trees at the Botanical Gardens of Kew had to be moved out of London to ensure their survival.

Great strides have been made to overcome such problems. Many West European countries now have laws regulating the type of fuels that may be burned to reduce smoke output. Also, ever taller smokestacks

have been built. Although this helped conditions in the immediate neighborhood of emission sources, it did nothing to improve the environment of regions farther afield.

Sweden's system of atmospheric monitoring stations, set up in 1952, eventually was extended to most of Western Europe, including the U.K. These stations began accumulating evidence of increasing sulfate and inorganic nitrogen compounds in rainwater, and falling pH values of the rain.

By 1968, sufficient information had been accumulated to allow Svante Odén, professor of soil science at the Swedish University of Agricultural Sciences in Uppsala, to make a detailed analysis of the data. Odén, who is credited with being the one to initiate the warning signals of the spread of acid rain, showed that a central area in Europe with precipitation more acidic, and containing higher amounts of sulfate and inorganic nitrogen than surrounding areas, had been expanding from year to year.

He clearly demonstrated the long-range transport to Scandinavia of sulfur dioxide and inorganic nitrogen compounds from the U.K. and from Central and Eastern Europe. He also established a link between this and the increasing acidification of lakes and rivers throughout Scandinavia where falling fish populations were being reported.

Odén, who warned of the likelihood of what he calls a chemical desert developing globally north of the 45th parallel unless air pollution is abated, joined with his Swedish colleagues in providing a detailed report on acidification and its consequences to the United Nations Conference on the Human Environment held in Stockholm in 1972. Influenced by this report, the Organization for Economic Cooperation & Development in Paris that same year launched what came to be known as LRTAP, the Cooperative Technical Program to Measure the Long-Range Transport of Air Pollutants.

LRTAP set out to determine "the relative importance of local and distant sources of sulfur compounds in terms of their contribution to air pollution over a region, special attention being paid to the question of acidity in atmospheric precipitation." Eleven West Eu-

ropean OECD member countries participated, with the Norwegian Institute for Air Research acting as the central coordinating unit.

It became evident, however, that the question of transboundary air pollution in Europe needed to be studied in a wider context, and that the East European countries, which aren't OECD members, should be brought into the discussions. So it was that the focus of activity shifted to the United Nations Economic Commission for Europe (ECE) in Geneva to which East-bloc countries belong.

In November 1979, 34 countries and the European Economic Community signed a convention on long-range transboundary air pollution, undertaking to "limit and, as far as possible, gradually reduce and prevent air pollution, including long-range transboundary air pollution." This convention became effective in March 1983, when it had been ratified by a sufficient number of signatories extending from Canada and the U.S. to the Soviet Union.

Prior to this convention, ECE also had set up a European Monitoring & Evaluation Program. Known as EMEP for short, sulfur deposition readings are made daily by national monitoring stations throughout East and West Europe using standardized equipment and techniques. The Chemical Coordinating Centre near Oslo collates the information and provides quality control of the data. Meanwhile the Meteorological Institute in Oslo and the Geophysical Institute in Moscow collaborate with one another on the verification of meteorological models with backup from the UN's World Meteorological Organization.

To date, measurements have centered mainly on sulfur dioxide and sulfates, along with pH values. There are two reasons for this. They were viewed as the principal actors early in the acid rain debate. Besides, methods for their measurement were well developed and fairly easy to carry out. Plans are under way to extend the readings to include nitrogen dioxide, ozone, particulates, and water conductivity, as well as anions (nitrate and chloride) and cations (ammonium, calcium, magnesium, potassium, and sodium).

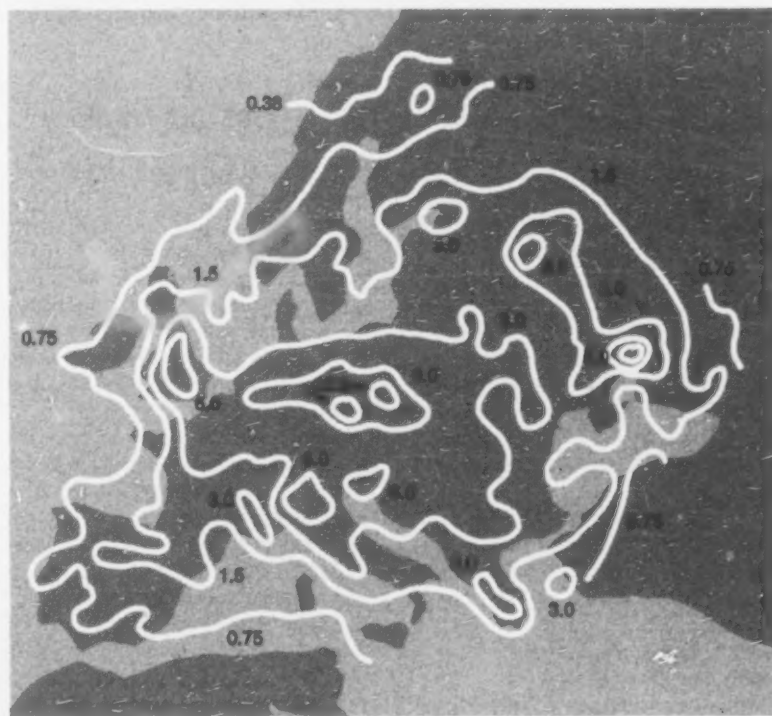
The present state of alarm about forest damage is focusing attention on the need for ozone measurements, comments Arne Tolan, a Norwegian hydrologist who heads ECE's air pollution unit in Geneva. "Few European stations can produce ozone concentration data right now because

the equipment is expensive," he explains. The main cost of the European monitoring program is paid by the national governments involved, he adds. In addition, there is a trust fund to support activities at the coordinating centers. The UN Environment Program contributes to the work.

A concept developing from this trans-European monitoring program is what people have come to call sulfur budgets. All countries generate sulfur dioxide from power stations, industries, and domestic sources, but some "export" more than they receive because of prevailing wind patterns. The reverse also is true, of course. A country's sulfur budget refers to the total annual sulfur deposition, both wet and dry, arising from its own and outside sources.

EMEP measurements show, for instance, that in 1983 the U.K. had an average monthly sulfur deposition of 847,000 metric tons, only 20% of which came from sources outside the country. In the case of Norway, on the other hand, the direction of the prevailing winds resulted in 92% of its 255,000-metric-ton average monthly sulfur deposition that year coming from elsewhere, mainly from the U.K. and from Central Europe. In West Germany, about half of the monthly sulfur deposition is emitted from within the country and half arrives from elsewhere, although the burden of "im-

Greatest concentration of sulfur deposition centers in Poland and Czechoslovakia



Note: Calculated total deposition of sulfur dioxide and sulfate ion from all emissions including background wet deposition for period October 1978 to September 1980. Units are grams sulfur per square meter per year.

Source: United Nations Economic Commission for Europe, European Monitoring & Evaluation Program



C&EN staff photos

Håberle (left): few people who stroll through woods are aware of damage. Odén (center): chemical desert could develop north of 45th parallel unless air pollution is abated. Overrein: acidification is a trans-world problem

ports" is much higher in the three regions of the country where forest damage has been noted.

When Lars N. Overrein, who heads the Norwegian Institute for Water Research in Oslo, speaks of long-range transport of air pollutants, he does so in global terms. "Acidification is a trans-world problem," he says. "Air streams traveling eastward over Scandinavia and further afield can carry oxides of nitrogen and sulfur along with other contaminants from the indus-

trial centers of eastern Canada and the U.S.," he notes. "The sources and environmental consequences of acid deposition often are separated by thousands of miles."

Strong acids have decreased the mean annual pH of precipitation in much of northwestern Europe and large areas of North America to between 4 and 4.5, he points out. The impact of such acidity on aquatic systems in the more susceptible areas of Europe and North America are clearly documented, he adds.

Acid rain legislation possible in U.S. in 1985, but not likely

Like garden variety perennials, acid rain bills keep popping up and dying off each Congress. The 99th Congress probably will not stand out as the exception.

On the day the new Congress convened, Jan. 3, Sen. Robert T. Stafford (R-Vt.) introduced the "Acid Rain Control Act of 1985" (S. 52). If it brings on déjà vu, it should. Stafford reintroduced the bill the Senate Environment & Public Works Committee approved last year.

Now—as then—the bill calls for a 10 million ton reduction in sulfur dioxide emissions in the 31 states east of the Mississippi River. The reduction is to take place over a 10-year period and is to be calculated from 1980 sulfur dioxide emission levels.

The Senate bill doesn't address the contribution that nitrogen oxides make to acid deposition. A committee staffer says that's because it's easier to

administer sulfur controls than nitrogen controls.

Probably because last year's version of this bill was overwhelmingly approved by the Environment Committee, Stafford chose not to reintroduce his own acid rain bill. Last Congress the Senator offered a bill that would have reduced sulfur dioxide emissions 12 million tons.

He may later introduce an acid rain abatement bill more stringent than the current bill. More likely, though, he may offer a bill that takes a different approach to control. He is now exploring alternatives to the tonnage reduction scheme found in all bills introduced to date. Perhaps, he says, it may be better "to mandate an emission limit, say, of 0.60 lb. per million Btu." in addition to studying the best way to control the problem, "we must ask ourselves whether the proper solution to the acid rain problem is not

to demand the achievement of a target, but to demand best efforts," Stafford insists.

Although members of the House Energy & Commerce's Subcommittee on Health & the Environment have not yet ruminated publicly on optional control schemes, they are giving thought to a major emissions reduction program. It would be even more encompassing than the so-called Waxman/Sikorski/Gregg (H.R. 3400) acid rain control program that nearly was approved by the subcommittee last year.

No House acid rain bill has yet been dropped into the legislative hopper. A health and environment subcommittee staffer says Rep. Henry A. Waxman (D-Calif.), who chairs the panel, is "waiting to see what the subcommittee is going to look like before he reaches a decision on whether to reintroduce H.R. 3400, or an entirely new bill."

That staffer suspects that Waxman

Overrein can speak with considerable authority on the subject. Before taking over his present position, he headed a Norwegian government-sponsored, eight-year joint research project titled "Acid Precipitation—Effects on Forest and Fish" that ended in 1980 (C&EN, June 14, 1976, page 14). Known as the SNSF project, short for the lengthy Norwegian title, one of the conclusions reached is that "there seems no reason to doubt that the change in the composition of the precipitation has played an important role in the acidification of fresh water."

Outcries from Norway and Sweden about falling pH readings in lakes and water catchments, and associated fish kills, didn't cause too much of a stir throughout the rest of Europe at the time. Indeed, many countries cold-shouldered the Scandinavians' calls for a limitation on sulfur dioxide emissions. Now, the recent evidence of tree damage and the belief that this is connected with increased acid deposition have made the Germans sit up and take notice. The Austrians, French, and Swiss, likewise, are voicing alarm over spreading damage in their forested areas. So it is that the governments of those countries have become ardent proponents of the so-called 30% Club.

The "club" takes its name from its aim, namely, that member countries commit themselves to cut annual sulfur emissions 30% from their 1980 base emission levels by 1993 at the latest. Proposed in 1983 by Finland, Norway, and Sweden, it got wide support at a ministerial conference in Ottawa last March. The first countries to join were Austria, Canada, Denmark, Finland, France, West Germany, the Netherlands, Norway, Swe-

den, and Switzerland. These have since been joined by Belgium, Belorussia (a part of the U.S.S.R.), Bulgaria, Czechoslovakia, East Germany, Italy, Liechtenstein, Luxembourg, the Ukraine, and the U.S.S.R.

Progress is well under way toward drawing up a protocol. The hope is that a text will be agreed upon at the working party's third meeting next month. If it is, it will go to the executive body's meeting in July. Assuming it passes that hurdle, the protocol will be sent to the national governments for ratification, at which point it will become a binding legal agreement.

Although there is overall consensus on the ideal of the 30% reduction, there are two broad differences of opinion as to how it should be viewed. Western, or noncommunist, countries want 30% sulfur dioxide reduction imposed on the emission sources. East-bloc countries, on the other hand, talk in terms of a 30% reduction of transboundary fluxes. Nevertheless, that there is a general meeting of the minds on the need to move toward lowering atmospheric sulfur dioxide is, in itself, a very positive step.

Doubtless West Germany is pleased that neighboring Czechoslovakia is in the club. That country is one of the black spots in the European sulfur deposition picture. (Southern Poland and northern Spain are the others.) Gaseous emissions from the concentration of heavy industries in the western region of Czechoslovakia have wrought havoc on trees in the area, which is not far from the Black Forest across the West German border.

Conspicuous by their absence from the 30% Club

and other committee members will offer a bill that mandates over a 10-year period at least a 10 million ton reduction in sulfur dioxide emissions and more than the 4 million ton reduction in nitrogen oxide emissions required in H.R. 3400. As he explains, the old bill called for stricter standards for nitrogen oxide emissions from new power plants and from new light- and heavy-duty trucks. This year, he says, the committee is going to look into nitrogen oxide emissions from off-the-road vehicles, and these emissions also may be enfolded into a control bill. Nitrogen oxide emissions from construction equipment, trains, and other off-the-road vehicles now account for 30% of the oxide levels in urban areas, the Environmental Protection Agency says. By 1995, the agency expects that figure to climb to 35%.

The staffer on the Senate Environment Committee acknowledges that there is increasing evidence for the role nitrogen oxides play in damages

associated with acid rain. And this accumulating evidence could warrant increasing controls on such emissions from mobile as well as stationary sources. Japanese studies, for example, have suggested a link between nitrogen oxide levels and adverse health effects. There is also evidence building for the role of oxides of nitrogen as well as of sulfur in forest damage, especially in the southeastern U.S.

Concern by Congressional members from upstate New York and the New England states is likely to remain the major pressure point for enacting acid rain legislation. But a staffer on the House Subcommittee on Health & the Environment believes that a factor of increasing importance in the debate will be the growing concern by influential members in the South over the economic consequences of forestry damage.

The question, of course, is whether all this concern can coalesce into a force powerful enough to enact acid

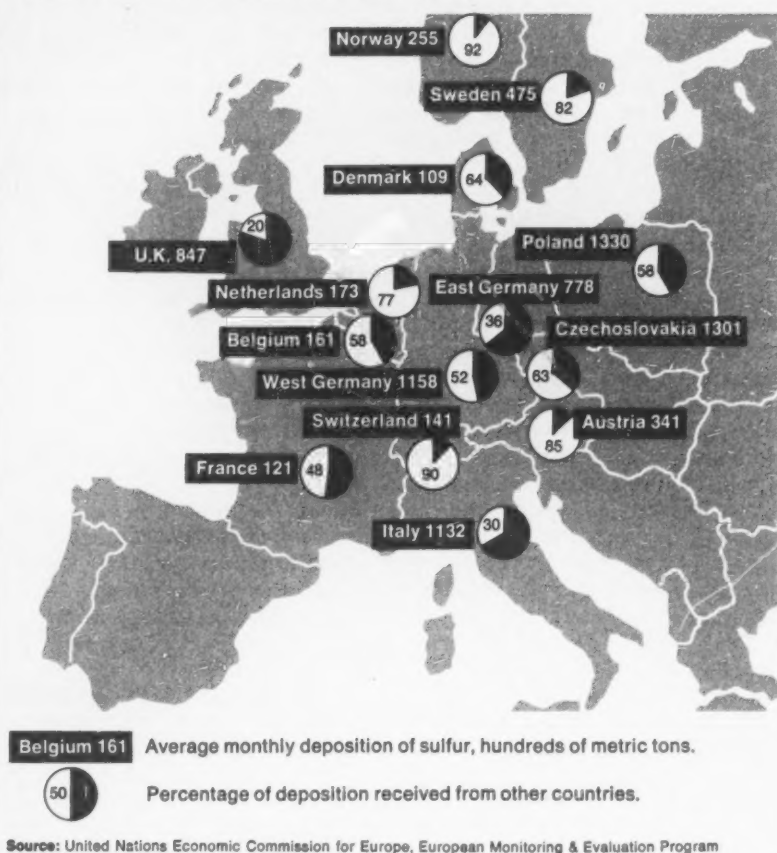
rain legislation. A House subcommittee staffer says, "If we can get a bill out of committee, it will be approved on the House floor. But without knowing who will be on the committee, it is hard to predict" what will happen at committee level. A Senate Environment Committee staffer says the problem in that body is "not getting a bill out of committee but having the leadership give us enough time to break a filibuster on the floor. If we're given enough time, we can probably get 65 to 70 votes."

The summary assessment for enactment of an acid rain control law: unlikely but not impossible.

The sticking point is, as always, economics. When Congress can figure out how to spread the pain equitably—as understood by the Midwest, the chief source of acid rain precursors—and when the White House supports acid rain curbs, then controls will be enacted.

Lois Ember, Washington

Most European countries import more sulfur pollutants than they produce



are the U.K. and the U.S. The U.K. is one of Western Europe's major sulfur dioxide producers and something of a thorn in the side of its neighbors, particularly Scandinavia, which claims to receive a large portion of U.K. emissions. Most of the sulfur dioxide comes from power stations operated by the U.K.'s Central Electricity Generating Board. The board's management argues with some justification that, compared with the other West European countries, the 30% cut in emissions based on 1980 levels would entail a disproportionate amount of expense. The U.K. already has brought down sulfur dioxide emissions from domestic and industrial sources some 40% during the past 10 years.

For the same reason, the U.K. is not pleased with a proposal drawn up by the Commission of the European Communities in Brussels that calls for a 60% reduction of sulfur dioxide emissions, and 40% each of nitrogen oxides and dust by 1995, from the corresponding annual mean levels recorded in 1980. The directive applies to combustion plants in the 10 member countries of the European Economic Community with a rated thermal output of 40 MW or more, regardless of the type of fuel used.

The cost to the U.K. power board and ultimately to the U.K. electricity consumer would be considerable if the directive were to become law. By the board's estimates, investment in the necessary hardware would amount to almost \$2 billion. Amortization and operating costs would come to about \$400 million a year. Against figures such as these, it probably came as no surprise that the U.K.'s ruling Conservative government earlier this month turned down a recommendation calling for a 60% cut in sulfur dioxide by 1995 made by the Parliamentary Environment Committee when its report was debated.

The power board, although objecting to undertaking such a large-scale expenditure, prides itself in funding one of Europe's largest research establishments dedicated to the environment. Moreover, Peter F. Chester, director of the company's technical planning and research division, argues that firm proof is lacking that sulfur dioxide is the prime factor in forest decline, and that it would be imprudent to invest so heavily in control equipment to meet the proposed emission standards until such proof is in.

Many among the scientific community and the public at large take issue with his view.

It is a fact, however, that some researchers point to nitrogen oxides, hydrocarbons, and ozone as being more critical factors, in which case automobile exhaust gases should be kept in check.

Moves already are being made in EEC to do just that. Lead additives are being phased out of gasoline to allow catalytic converters to be used. By October 1995, exhaust emission standards matching those currently in force in the U.S. will go into effect.

In this connection, West Germany has stolen the march on its EEC partners. Last year it decided to make catalytic converters compulsory by 1989.

Sweden's Svante Odén is still acutely concerned that acid deposition will inevitably cause the continuing decline of ecosystems unless widespread moves are made to reverse the trend. He privately harbors the view that taxation could be roped in as an ally. He suggests that a levy of 5% or so could be imposed on all fossil fuels. The income would go to an international fund for distribution to help pay for development of the necessary emission control technology and distribution of the know-how worldwide. Indeed, such a concept might usefully be incorporated in the ECE convention. □

Chemical Stocks Performed Poorly in 1984

Confidence in chemical company earnings eroded as 1984 progressed, driving their stock prices down faster than others

William J. Storck, C&EN New York

Last year chemical stocks were not a very good investment. Although they performed well in the first half of the year, the seeming moderation in economic growth and thus in the stocks' earnings outlook in the second half of 1984 drove them well below their level at the end of 1983.

Specifically, C&EN's chemical stock index declined 20% by the last Friday of the year, compared to the final Friday in 1983, and the stock prices for 30 chemical companies

followed by C&EN fell an unweighted average of 8%.

The reasons for the stock price declines are many, but since prices are generally based on forecast earnings, the reasons are practically the same as those that have slowed earnings growth in the second half of the year. Chief among these are lack of price growth and dismal foreign trade brought on by the high value of the dollar against foreign currencies.

Producers have long been complaining that chemical pricing is going nowhere. Price inflation for chemicals in the past two years generally has been below that of the total economy and, although it makes little difference in the long run, their prices have been held down by falling commodity costs. For instance, even though natural gas is the largest petrochemical feedstock in the U.S., producers of pet-

rochemicals say that their customers balk at price increases because of falling oil prices, confusing oil with natural gas as the primary feedstock. It is more of a psychological rather than real factor in pricing, they say. Then too, attempted price increases have not been helped by the continuing large overcapacity for many chemicals.

One of the main reasons for current excess capacity is the foreign trade situation. Normal overseas outlets are being shut off from U.S. producers because the high value of the dollar is pricing U.S. products out of the international market. That market traditionally has been the safety valve for U.S. chemical products when U.S. demand is not enough to soak up production. Since this safety valve no longer exists, producers cannot run plants at the speed at which they historically had been able during previ-

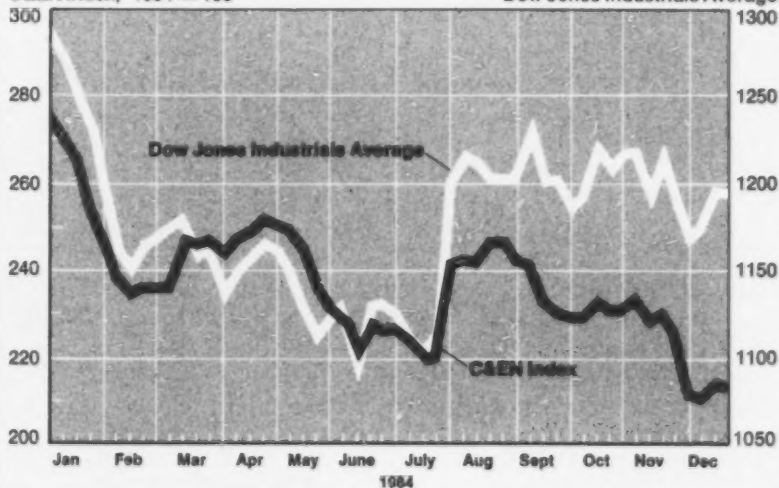
All major indexes outperformed chemicals last year

	Dec. 28, 1984	Dec. 28, 1983	% change
Dow Jones Industrials Average	1204.17	1258.64	-4.3%
New York State Exchange Composite	95.89	95.18	0.7
New York State Exchange Industrials	110.14	111.35	-1.1
American Stock Exchange Index	202.79	223.01	-9.1
Over-the-Counter Composite	249.08	278.60	-11.7
Over-the-Counter Industrials	258.94	323.68	-20.0
Standard & Poor's 500	186.26	184.93	0.8
Standard & Poor's 400 Industrials	185.49	186.24	-0.4
C&EN Chemical Stock Index	214	269	-20.4

Chemical stocks lost more ground than industrials in 1984

C&EN Index, * 1954 = 100

Dow Jones Industrials Average



* C&EN index based on stock prices for Allied Corp., American Cyanamid, Celanese, Dow Chemical, W. R. Grace, Monsanto, and Union Carbide.

Biotechnology-related stocks fared dismally in 1984

One small investor, having taken a several-thousand-dollar flier on a newly hatched biotechnology company in early 1983, has glumly watched the value of his shares plummet to less than half of what he paid for them. As an executive of a major pharmaceutical company and holder of a doctorate in microbiology, he says he still believes in the promise of the biotechnology company's developmental products. He admits, nevertheless, to being a little nervous about his investment.

He is unlikely to be alone in that feeling. Biotechnology stock prices fell like Icarus last year. Excepting a flutter of life during the stock market's short-lived August rally, they dropped more or less steadily from the year's high point, reached in late January. When the exchanges closed on Dec. 28, the average weighted price of a universe of a dozen such stocks was a third lower than it had been at the beginning of the year.

There were exceptions to the general fall from grace, of course. The value of shares of Applied Biosystems rose dramatically over the course of the year, attaining a record high of \$31½ in late November before falling back to \$29 per share at the close of the year. But Applied Biosystems' products are mainly instruments and other supplies sold to biotechnology researchers. Among the more-or-less "pure play" biotechnology firms—those

either manipulating genes or manufacturing products based on monoclonal antibodies—Genentech's stock was the most successful. That is to say, the price per share fell only 2% over the course of 1984. And shares of Hybritech, after touching bottom at \$11 a share in July, rebounded strongly to finish the year at \$16.

On the whole, though, it was a dismal year for biotechnology-related stocks. Partly, such stocks suffered from the investment community's general turn away from high-technology and medical growth stocks last year. Even more, say analysts, investors became exasperated as they realized that substantial earnings were probably further in the future than they had anticipated. As a result, even when companies were meeting business plan targets more or less on schedule, interest in their stocks waned.

"The projects may be going according to plan," says Parag Saxena, biotechnology and medical technology analyst at Citibank, "but are they being converted to products yet? No. People realized that will be slower than expected."

Another analyst, Sarah Kendall Bayles of Dean Witter, points out: "Visibility may have improved as far as projects go, but earnings visibility didn't improve."

The decline brought many stock prices to all-time company lows in

1984. Among such unwanted records, Amgen shares sank to \$3¾ in late November; Biogen shares touched bottom at \$4¼ in early December; Centocor hit \$8 in December; Cetus sank to \$8⅝ in December; Damon Biotech sank to \$4½ in December; Genetic Systems hit a low of \$4½; Genex sank to \$4¾ in December; Hybritech, as mentioned above, fell to \$11 in July; Molecular Genetics fell to \$6 in late November; and Monoclonal Antibodies sank to \$8.

The question now is how these stocks will fare in 1985. They'll do better, if early indications have any predictive value. The price of many biotechnology-related stocks moved up smartly over the first two weeks of the new year. Genentech is a particularly notable example of this. After closing at \$33¾ on Dec. 28, the price of a share had risen to \$40½ Jan. 16.

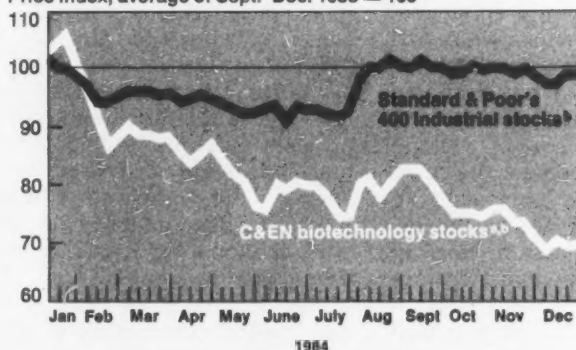
Other firms whose stock prices rallied noticeably during the first two weeks of the year (as of Jan. 16 closing) are: Biogen, to \$7¾; California Biotech, to \$6½; Centocor, to \$11; Cetus, to \$10; Collaborative Research, to \$5½; and Hybritech, to \$19¾.

"This year we will see some sorting out of companies for better and worse," says Citibank's Saxena, "that will distinguish those companies that have projects that are far out from those with projects that are near."

David Webber, New York

Biotechnology stocks performed worse than rest of stock market . . .

Price index, average of Sept.-Dec. 1983 = 100



a Based on stock prices for Amgen, Applied Biosystems, Biogen, Centocor, Cetus, Damon Biotech, Genentech, Genetic Systems, Genex, Hybritech, Molecular Genetics, and Monoclonal Antibodies. b Reindexed to average for Sept.-Dec. 1983 period to show relative change. Prices as of Friday close each week.

. . . and prices fell an average of nearly a third in 1984

Company	Year-end price ^a	Change ^b	52-week range	
			High	Low
Amgen	\$ 4¾	-34%	\$ 8¼	\$ 3¾
Applied Biosystems	29	61	31½	16½
Biogen	5½	-49	14	4¼
Bio-Response	4	-42	14¾	3⅝
California Biotech	5½	-54	13¾	4¼
Centocor	8¾	-33	16¼	8
Cetus	9	-17	14	8⅝
Collaborative Research	4⅝	-35	10¾	3⅝
Damon Biotech	4⅝	-42	10½	4½
Genentech	33¾	-2	42¼	28¾
Genetic Systems	5½	-39	10¾	4½
Genex	5⅝	-59	17¼	4¾
Hybritech	16	-15	23	11
Molecular Genetics	7½	-38	16¼	6
Monoclonal Antibodies	9	-25	15½	8

a As of Friday, Dec. 28, close. b Dec. 30, 1983, to Dec. 28, 1984.

Stock prices fell for most chemical companies in 1984

	Yearly close	12-month		% annual change ^a	Price/earnings ratio ^b		Dividend yield ^c	
		High	Low		1984	1983	1984	1983
Air Products	\$48	\$48 1/2	\$36 1/2	3%	10	13	2.6%	2.2%
American Cyanamid	60	53 1/2	42 1/2	0	11	16	3.8	3.5
Celanese	81 1/2	82	62 1/2	18	7	23	5.4	5.8
Chemel	26 1/2	36 1/2	24 1/2	-27	11	16	5.6	3.7
Crompton & Knowles	21 1/4	23 1/4	19 1/4	-10	9	12	5.7	4.8
Dow Chemical	27 1/2	34 1/2	25 1/4	-18	10	26	6.5	5.4
Essex Chemical	20 1/2	22 1/2	15 1/2	-4	10	13	4.0	3.8
Ethyl	32	33 1/4	20	25	11	10	2.7	3.3
First Mississippi	8 1/2	13 1/4	7 1/4	-28	9	25	2.7	2.0
Freeport-McMoRan	16 1/4	25 1/4	13 1/2	-17	13	26	3.6	3.0
H. B. Fuller	14 1/2	16 1/4	11 1/4	-26	10	13	2.1	1.4
W. R. Grace	39 1/2	46 1/2	36 1/2	-12	10	14	7.0	6.2
Hercules	33 1/2	38	27 1/4	-5	9	14	4.7	4.0
International Flavors	28	29 1/4	22 1/2	3	15	15	4.0	4.0
International Minerals	37 1/4	49	32 1/2	-14	11	14	7.0	6.0
Loctite	34	42 1/4	30 1/2	-18	13	21	2.4	1.4
Lubrizol	21 1/2	24 1/2	16 1/4	-2	13	15	5.4	4.9
Monsanto	44	53 1/2	40 1/2	-16	8	12	5.2	4.0
Morton Thiokol	27 1/2	31 1/2	20	7	12	14	2.3	2.3
Naico Chemical	26 1/2	33 1/4	21	-15	14	20	4.5	3.9
National Distillers	26 1/2	30	22 1/4	-5	13	20	8.4	8.0
Olin	30	33 1/2	25 1/2	-2	8	13	5.0	4.3
Pennwalt	39	42 1/4	31 1/2	-4	10	19	5.6	5.4
Petrolite	26 1/4	32 1/2	24 1/2	-7	13	15	4.3	3.5
PPG Industries	32 1/2	38	24 1/4	-6	8	12	4.4	3.7
Reichhold Chemicals	32 1/2	35 1/2	23	-2	9	15	2.5	1.8
Rohm & Haas	63 1/2	69 1/4	48 1/2	5	9	12	3.1	2.6
Stauffer Chemical	17 1/2	25 1/4	15 1/4	-30	34	def	8.2	5.8
Union Carbide	36 1/4	65 1/4	32 1/4	-41	13	20	9.3	5.4
Wilton Chemical	34	39 1/2	27 1/2	-4	8	11	4.4	3.7

a From year's end 1983. b As of year end. c Dividend as percentage of stock price.

ous recoveries. Add to this the problem that the value of the dollar is making imports cheaper and more competitive with U.S. products, thereby taking up some of the domestic demand, and one can easily see that foreign trade is giving the chemical industry and its earnings fits.

In addition, there is concern about the industry itself—concern about the costs of regulation and concern about what direction the industry is taking. This latter is manifest in analysts' discussions of the maturity of the industry and its moves to find higher-value-added products. Many analysts, although applauding the moves into specialties or diversification by the industry, are taking a wait-and-see attitude toward the transformation. They point out that the industry is so dominated

by large-volume basic chemicals that it will take some time and a lot of investment before the diversification moves will make themselves felt.

The result is that despite good performance in the first half of 1984, the earnings outlook for chemicals since then has just not been that good—and it continues to be lackluster.

Hence, stock prices for the chemical industry have fallen and are continuing to stay down. The 20% drop in C&EN's chemical stock index in 1984 was matched only by an equal fall in the Over-the-Counter Industrials. The most widely quoted of the market indicators, the Dow Jones Industrial Average, fell just 4% between the end of 1983 and the end of 1984. And two of the very broad indicators—the New

York Stock Exchange Composite and the Standard & Poor's 500—actually managed almost 1% gains.

Of the 30 stocks surveyed by C&EN, only six—Ethyl, Celanese, Morton Thiokol, Rohm & Haas, Air Products, and International Flavors & Fragrances—managed an increase through 1984. One, American Cyanamid, held even with the end of 1983. The remaining 23 all showed declines of 2 to 41%. At the high end of that range, 41%, was Union Carbide, which probably is a special case because its stock price fell 24% in December in the aftermath of the Bhopal, India, tragedy. Before the Bhopal incident, Carbide's stock price had dropped just 22% from the end of 1983.

The situation at year's end could have been worse for the companies, however, since they were closer to their yearly highs than they were to their lows. The average stock price for the 30 companies at the end of the year was up 22% from the average 12-month low, but down just 15% from the average 12-month high for the group.

Reflecting the lack of earnings confidence in the group, the average price/earnings ratio dropped during the year. At the end of 1983, when the recovery was well under way and earnings expectations for chemicals were rosy, the average price-earnings ratio for the 30 companies was 16. However, as confidence eroded, so did the ratio, until at the end of 1984 it had sunk to just 11. This average would have been even lower but for Stauffer Chemical, which finished the year with a price/earnings ratio of 34 on a dismal earnings performance.

For this year it seems like more of the same. Analysts still see problems continuing for the industry—problems such as pricing, foreign trade, and regulatory costs, the last of even more concern since Bhopal. And they have added a few new ones, chief among them slowing of production brought about by declining demand in the general economy and inventory reduction among downstream customers. Thus, analysts expect nothing great from chemical stocks in 1985. In fact, they seem to be on few recommended lists. □

Engineering resin demand rose sharply last year

U.S. consumption of engineering resins spurted 18% last year over 1983 to a record 1.15 billion lb, according to Frank M. O'Neill, business director for Celanese's engineering resins division. Worldwide, use of these plastics vaulted 14% to 3.05 billion lb, he says. These figures include nylon, polycarbonate, polyphenylene oxide, polyacetal, polytetramethylene terephthalate, polysulfone, and polyphenylene sulfide, and do not include fluoropolymers or acrylonitrile-butadiene-styrene (ABS).

Celanese's own sales of nylon, polyacetal, and polytetramethylene terephthalate also increased 18%, O'Neill says, both in the U.S. and through its West German and Japanese affiliates. Those affiliates are

Ticona Polymerwerke, a joint venture with West Germany's Hoechst, and Polyplastics Co., a joint venture with Japan's Daicel.

Celanese has begun a \$35 million debottlenecking of its polyacetal facility at Bishop, Tex., expanding capacity to 155 million lb per year from 120 million lb, slated for completion in 1985. The company also will build new engineering resin plants in Brazil and Mexico. In December, Celanese started up a 9 million lb-per-year compounding plant at Florence, Ky. Thomas C. Bohrer, vice president and general manager of Celanese's engineering resins division, has estimated that compounds for specialized cost-performance niches will grow to 30% of all engineering plastics by 1991.

O'Neill cites high auto sales in 1984 coupled with continued increase in weight of plastics per car as one reason for the strong showing of engineering resins in the U.S. Another factor was increased housing starts, which led to greater sales to plumbing, appliance, and hardware industries. A third contributor was electrical and electronics sales, spearheaded by personal and small business computers. Overall, routine use of computer-aided design and manufacture catalyzed continued replacement of metals by plastics, O'Neill says.

These same economic considerations sparked growth in other parts of the world, he says, where concerns to save energy were an additional factor. Continued economic strength in Japan, recovery in Western Europe, and increased exports to developing countries brought a rise in exports from the U.S. About 20% of U.S. engineering resin production is exported now, up from 16% in 1979.

For the future, O'Neill predicts that 1985 again will be a strong growth year in the U.S., with sales of engineering resins advancing 7 to 8% to 1.23 billion lb. Saturation of end-use markets will slow growth to 3 to 4% in 1986, he adds, reaching only 1.28 billion lb. A renewed surge of growth after that likely will top 1.7 billion lb in 1989, O'Neill concludes.

U.S. engineering resin use hit record high in 1984 . . .

Millions of lb	Percent of world Total	
U.S.	World	Total
Nylon	403	841 1244
Polycarbonate	300	345 645
Polyphenylene oxide	175	183 358
Polyacetal	128	374 502
Polytetramethylene terephthalate	120	142 262
Polysulfone	13	5 18
Polyphenylene sulfide	10	10 20
TOTAL	1149	1800 3048

. . . led by these markets . . .

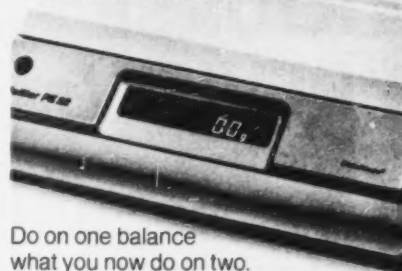
	% of sales	% annual change
Transportation	28%	10%
Construction ^a	13	8
Electrical & electronics ^b	25	15
Industrial machinery	15	3
Other ^c	19	8

. . . and is poised for strong growth

Millions of lb	1984	1983	% annual change
U.S.	1149	1703	8-8.5%
Japan	616	926	8-9
Western Europe	1028	1343	5-6
Other	255	330	5-5.5
TOTAL	3048	4302	7-7.5%

^a Housing, plumbing and hardware, appliances, glazing and lighting. ^b Business machines, industrial, communication, recreation, consumer goods, packaging. ^c Source: Celanese

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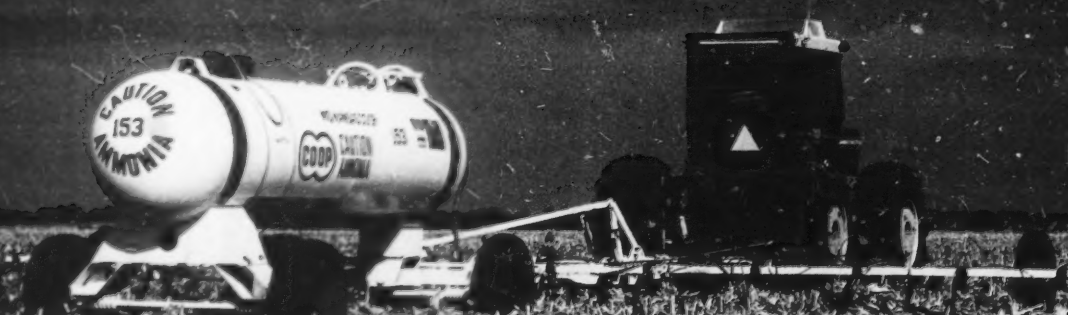
**FEB
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1985**

Federal policy makers, industry
chiefs debate biotechnology regulation
Page 21

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CHEMICAL & ENGINEERING

NEWS



**Gas-based
Petrochemicals**
Agriculture markets among those hurt
by growing imports Page 10

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News of the Week

■ Proposed major revisions to EPA's guidelines for cleanup of toxic waste sites would speed up action and reduce paperwork. **Page 6**

■ Workforce reductions at Du Pont and Hoffman-La Roche affect thousands of employees. **Page 7**

■ Researchers document relationship between blood pressure and blood lead levels. **Page 7**

■ FDA approves oral drug that can help prevent recurrent outbreaks of genital herpes. **Page 7**

■ More toxic gas leaks at Institute, W. Va., reported to EPA by Union Carbide. **Page 8**

Cover: Preplanting application of anhydrous ammonia to midwestern cornfield. Photo courtesy of Farmland Industries Inc.

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Business

Growth in demand for reinforced plastics is expected to slow this year, even though plastics shipments will set a record. **Page 15**

International Business

West European chemical makers fear Saudi petrochemicals operations will cut into their local and export markets. **Page 16**

Mexican producers of PVC hope export business will take up slack of low domestic demand, bring in foreign exchange. **Page 18**

Government

Biotechnology conference brought together government officials, business leaders to discuss definitions, public policy. **Page 21**

Technology

New Dow processes for making acrylate esters come out of continuing C₁ chemistry program. **Page 25**

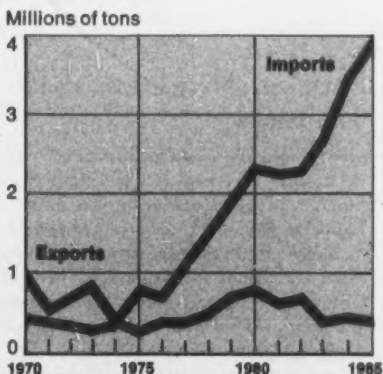
Science

Changes in the group notation of the periodic table are designed to remove ambiguities in the previous format. **Page 26**

Computer software program developed by Arthur D. Little estimates chemical and physical properties of organic chemicals. **Page 27**

Books

"Mammalian Semiochemistry" by Eric Albone provides a guided tour through areas of research on chemical signals. **Page 28**



Cover Story

U.S. producers of petrochemicals based on natural gas face slowdown in production owing to negative trade balance. **Page 10**

Production Slows for Natural Gas-Based Petrochemicals

Slowdown, caused by negative trade balance, coupled with steady demand for products could increase dependence on ammonia, methanol imports

Bruce F. Greek, C&EN Houston

A long-expected shift to a negative trade balance has occurred for chemicals made in the U.S. mainly from natural gas. That shift is causing a slowdown in production of ammonia, urea, and methanol, even though demand for these products is remaining steady or even increasing slightly.

And with the prospects good that U.S. production capacity for gas-based chemicals will decline, the longer-term result could be a greater dependence on foreign sources of ammonia and methanol. Currently, demand—exports and U.S. consumption—for ammonia, methanol, and their derivatives is about equal to supply—production plus imports.

However, if U.S. consumption were to rise or imports decline, exports likely would have to be cut to provide supplies to meet demand, further contributing to a negative trade balance.

Economics now seem to be less favorable for production of these chemicals in the U.S. than in some foreign countries. Consequently, more U.S. plants could be shut down, and those already down would become less likely, because of deterioration, to restart. Eventually, capacity to make ammonia and

by two conditions. One is that the new plants built in countries having low-cost natural gas also supply product to markets once supplied by U.S. exports. Because of the lower-cost feedstock at the foreign plants, U.S. exports no longer are price competitive. The other involves the exports to the U.S., which often sell at prices below U.S. producers' costs. Such sales cut into U.S. producers' sales so much that operating a plant no longer is profitable. Thus, capacity is reduced, making product for export from the U.S. less available.

This contributes to a rise in chemical imports. The strength of the dollar adds incentive for export to the U.S. Longer term, even if a weakening of the dollar occurs, the cost advantage now enjoyed by foreign producers won't go away and most likely will increase. This means that even more U.S. ammonia and methanol capacity will be shut down.

For details of the near-term outlook for ammonia, urea, methanol, and formaldehyde, see the following pages.

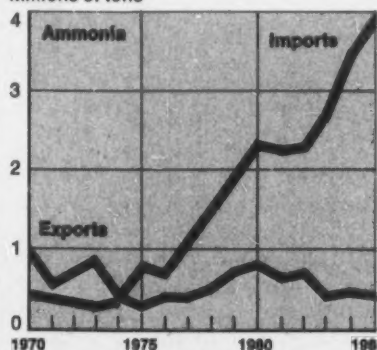
Key Chemicals

methanol and their derivatives could become inadequate if demand were to surge because of weather or increased planting following a crop failure. Higher prices could increase imports if they are available, but also could compound the shortage problem.

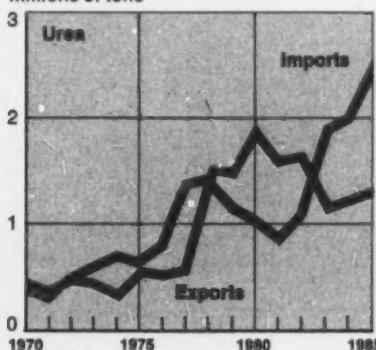
The decline in ammonia, urea, and methanol exports is being caused

U.S. trade imbalance grows for gas-based petrochemicals

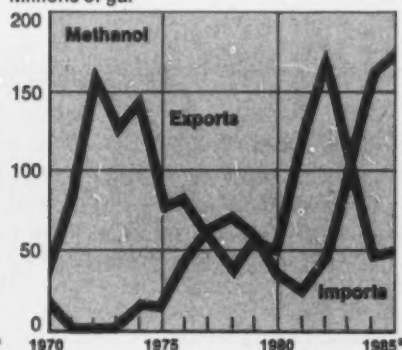
Millions of tons



Millions of tons



Millions of gal



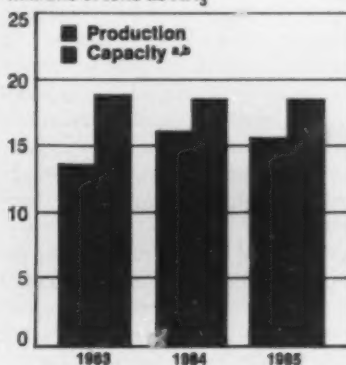
Note: Trade in formaldehyde is negligible because of high transportation costs for solution. * 1984 and 1985 are estimates.
Sources: Department of Commerce, C&EN estimates

Ammonia

- Demand uncertain
- Capacity holding
- Prices steady

PRODUCTION/CAPACITY

Millions of tons as NH₃



a First quarter. b Some capacity shut down.

MAJOR PRODUCERS

CF Industries, Columbia Nitrogen, Farmland, Union Oil, Williams Cos. (Agrico)

HOW MADE

Catalytic reaction of nitrogen from air and hydrogen from natural gas

MAJOR DERIVATIVES (U.S.)

Ammonium nitrate 20%, urea 20%, ammonium phosphates 15%

MAJOR END USES (U.S.)

Fertilizers 80%, fibers and plastics 10%, explosives 5%

FOREIGN TRADE

Exports—declining to about 400,000 tons for 1985, imports—rising to nearly 4 million tons for 1985

PRICES

List prices about \$150 per ton on Gulf Coast

Ammonia producers can expect this year to be much like 1984, with little change in production or consumption. At most, demand may rise slightly and production decline a bit.

Currently, demand for ammonia is holding steady, neither high nor low by recent standards, as the planting season gets under way in the warmer sections of the U.S. Most ammonia plants in this country are operating now, ammonia inventories are believed to be about normal, and prices are at about the level they were a year ago. Whether these circumstances will continue throughout 1985 will strongly influence industry profits.

Consumption of ammonia as a fertilizer or in making fertilizers used on U.S. fields probably will be slightly below or equal to that of 1984, depending on money and weather conditions. Feeds and industrial uses could be down perhaps 2 to 5% from their 1984 patterns.

Chemical nitrogen includes both fertilizer and nonfertilizer nitrogen. (Examples of nonfertilizer-nitrogen-containing end products are nylon and melamine.) Total chemical nitrogen consumption during 1985 might be up by a small amount—1 to 2%. That gain would result from higher exports of nitrogen fertilizers, especially diammonium phosphate.

However, an increase in consumption will not necessarily increase ammonia production in the U.S.; output most likely will decrease as much as 5% from last year's 16 million tons or so. Instead, the increased consumption will be supplied from rapidly rising imports, even as U.S. production of ammonia declines. Ammonia exports are relatively small compared to imports and are expected to decline in 1985. Thus a larger deficiency in U.S. nitrogen production relative to consumption will result. Other imported chemical nitrogen fertilizer materials will offset exports of such materials and go largely to fertilizer use.

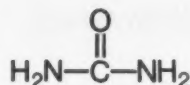
The export-import situation for am-

monia alone makes many in the industry uncertain about the outlook for 1985. Other unknowns such as weather, grain prices, grain export demand, and farm financial conditions make many industry sources admit that their forecasts are no more than educated guesses. But a rough consensus developed from a number of these sources is that U.S. ammonia production will drop less than 5% from 1984 to about 15.5 million tons. Most large-sized plants—those with capacities of 1000 tons per day—will operate most of the year with about 30 days downtime for routine maintenance. Smaller plants that survive because of special marketing situations generally will run as much as needed to keep their market and to maintain a reasonable inventory. As a result, the average operating rate for U.S. plants this year will come to about 85% of nameplate capacity.

Ammonia's consumption pattern in 1985 will be similar to that of recent years, with no new uses of any size expected. None of the nonfertilizer uses of ammonia and its derivatives—which account for about 20% of total U.S. demand—are large enough to have a major impact on the total use, even if consumption should change greatly. Industrial uses, such as those in making acrylic and nylon fibers, explosives, and many small chemical intermediates and their end products, could show minor variations in ammonia demand as their production is influenced by such matters as garment imports, reduced mining activity and changes in preferred explosives, and industrial operations.

If these early forecasts prove accurate, ammonia will have almost as good a year as it did in 1984. But in the face of rising imports from countries with low-cost gas feedstocks, ammonia production in the U.S. is facing the unpleasant prospect of a continuing decline in the next several years unless U.S. natural gas prices drop drastically.

Key Chemicals

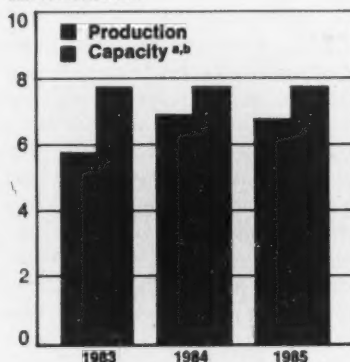


Urea

- Demand may rise
- Capacity on hold
- Prices under pressure

PRODUCTION/CAPACITY

Millions of tons



a First quarter. b Some capacity shut down.

MAJOR PRODUCERS

CF Industries, Columbia Nitrogen, Farmland, Union Oil, Williams Cos. (Agrico)

HOW MADE

Reaction of ammonia and carbon dioxide under pressure

MAJOR DERIVATIVES (U.S.)

Urea-formaldehyde resins 5%

MAJOR END USES (U.S.)

Fertilizers 80%, animal feeds 10%, adhesives and plastics 5%

FOREIGN TRADE

Exports—may rise slightly to above 1.25 million tons in 1985, imports—rising rapidly to around 2.5 million tons in 1985

PRICES

List prices about \$150 per ton on Gulf Coast

The outlook for production of urea in 1985 holds uncertainties similar to those for ammonia. These uncertainties could be extended as well to other high-nitrogen-content fertilizers that often compete with urea and ammonia.

At this time, however, urea production, inventories, and selling conditions are running about normal for this time of the year. Changes could come in all of these factors, caused by changes in demand, as a better idea of the success for fertilizer sales develops this spring along with the outlook for housing, which is the major nonagricultural end use for urea.

Based on early forecasts, urea producers will not have nearly so good a year in 1985 as they did last year. In 1984, production of urea reached an estimated 6.9 million tons, up some 19% from 1983. In 1985, production probably will be down slightly, less than 5%, to the 6.5 million to 6.7 million ton range.

Forecasts for 1985 urea production attempt to take into account U.S. consumption of urea and the net difference between imports and exports. The domestic consumption of urea will depend on many of the usual conditions, starting with weather, actual applied costs relative to similar costs of other fertilizer nitrogen sources, and planted acreage.

Weather, while not so absolute a factor as cost, can heavily influence urea use. If the spring weather provides generally dry and relatively easy-to-work fields, anhydrous ammonia will be used more heavily than urea. Urea-ammonium nitrate solutions rank in between.

The costs of applied fertilizer nitrogen to farmers and planters rank first, as might be expected, in most decisions of which material to use. Shifts in prices of ammonia and urea at plant sites bring even larger swings in prices that farmers pay. Therefore, substitution could become important, especially as farms get larger and purchases of fertilizer and the cost of its

application account for large amounts of money to the individual farmer.

Prices of nitrogen fertilizers are strongly affected by the trade situation. Imports of urea have risen rapidly and may exceed 2.5 million tons in 1985. As is the case with ammonia, imports of urea from countries with large, low-cost supplies of natural gas offer many benefits to the exporting countries. Generally, hard currency is obtained, and the gas is exported in a profitable form in contrast to little or no use as yet in the producing country. Plant operating problems have limited some countries' urea exports to the U.S. in the past, but now perhaps experience has reduced these problems.

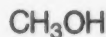
Exports of urea from the U.S., especially to the Far East, continue at higher levels than were anticipated some years ago. However, they are well down from the peak of nearly 2 million tons set in 1980, with rough estimates for 1985 at about 1.25 million tons.

This net trade imbalance of about 1.25 million tons of urea in 1985 will keep plant operating rates lower than desirable for good profitability at about 85% of nameplate capacity. Some of the small plants either will continue their current shutdowns or will be shut down after the main fertilizer season is over. This will indeed be true for those that depend on an adjacent ammonia plant for a supply of carbon dioxide.

The feed and industrial markets for urea take about 15% of U.S. consumption. Feed use always faces strong price competition from other sources of nitrogen such as molasses, so probably will not grow much if at all. Industrial uses are dominated by urea-formaldehyde resins used as adhesives for particle board for interior construction, especially for housing—a use that may remain unchanged or decline slightly in 1985.

Urea, then, will have a slightly down year with production declining after a good recovery in 1984.

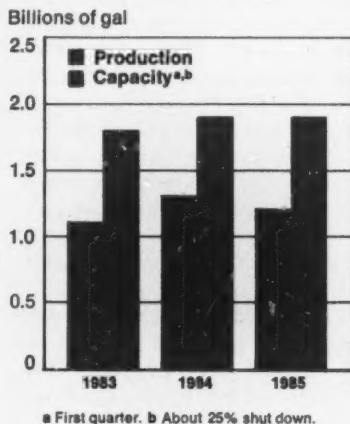
Key Chemicals



Methanol

- Demand soft
- Much capacity down
- Prices weak

PRODUCTION/CAPACITY



MAJOR PRODUCERS

Arco Chemical, Borden, Celanese, Du Pont, Texaco

HOW MADE

Reaction of carbon monoxide and hydrogen made by reforming natural gas (methane) or heavier hydrocarbons; or by coal gasification

MAJOR DERIVATIVES (U.S.)

Formaldehyde 30%, acetic acid 10%, chloromethanes 10%

MAJOR END USES (U.S.)

Polymers used as adhesives, fibers, and plastics 50%

FOREIGN TRADE

Exports—slowing to under 50 million gal in 1985, imports—rising to more than 175 million gal

PRICES

About 40 cents per gal in volume sales on Gulf Coast

With no new uses, including the much talked about fuel uses, to push up demand, methanol production will decline a small amount in 1985. Pressure will remain on prices because of the possibility of more imports. Profitability will remain marginal for operating plants, making methanol production a business segment of the chemical industry from which an exit seems attractive.

Production of methanol in 1985 will total about 1.2 billion gal, down 8% from last year. This decline will result from higher imports to help satisfy U.S. demand. Depending on future pricing, the slow decline in methanol production could be setting the pattern for the future.

Capacity to make methanol exceeds estimated production in 1985 by more than half. This will cause the operating rate to be less than 65% for all of this year, assuming that all capacity is operable and that demand will be large enough to allow production to reach 1.2 billion gal.

Amazingly, the industry currently has more than one third of its capacity shuttered. How much of this shut-down capacity will run again remains a big question. If past experience is any indicator, quite a bit of it will never run again. The time between shutdown of capacity and actual scrapping can be many years.

The two thirds of total U.S. methanol capacity still operating will be running almost full out this year. Such a situation leaves little margin for any kind of maintenance downtime beyond the routine or for any major plant modifications that would help efficiency.

The methanol industry currently is working off some excessive inventories built up during the latter part of 1984. Moreover, imports of methanol are readily available at only slightly higher prices from several countries, such as Canada, Trinidad, and Saudi Arabia. If U.S. production becomes limited for any time as a result of a plant mishap. The use pattern for meth-

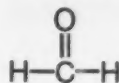
anol continues to change slightly with some effect on total consumption. The largest use, formaldehyde, is losing market share to newer uses such as the octane value additive, methyl *tert*-butyl ether (MTBE), and the use of methanol itself as a fuel. MTBE and fuel uses are past their growth spurt and this year will account for about 15% of methanol consumption. Formaldehyde use has dropped from 45% a decade ago to 30% of U.S. consumption.

If methanol prices rise much—a development that even the more hopeful methanol producers don't expect until at least late in the second quarter—or if the price of natural gas to methanol producers declines, then one or more plants could be restarted as a result of better economics.

For now, however, producers of methanol who have to pay upwards of \$2.50 per 1000 cu ft of natural gas barely are recovering their cash costs when they sell their methanol for 40 cents a gal, a typical methanol price for large volumes at plants on the Gulf Coast. If they have old gas contracts—which are now quite rare—for much lower prices, then they could be getting some profit on methanol sales. If they have captive uses for methanol such as making it into formaldehyde and then using the formaldehyde for some higher-value end product, their overall profitability could be better.

The real key to any restart of shut-down methanol capacity now remains the cost of natural gas. Price of methanol ranks next because if it should rise significantly, then more imports would arrive promptly on the U.S. market and quickly put pressure on the higher prices. World crude oil prices now are declining, putting pressure on natural gas prices wherever heating oil might be substituted for gas. But U.S. natural gas prices are unlikely to decline enough to make production costs low enough for keeping out imports of methanol from countries where gas costs are one tenth to one quarter those in the U.S.

Key Chemicals

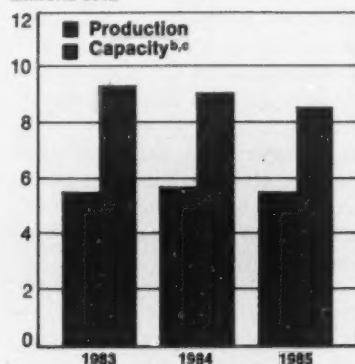


Formaldehyde

- Demand off a bit
- Capacity holding
- Prices level

PRODUCTION/CAPACITY

Billions of lb^a



^a As a 37% solution. ^b First quarter. ^c Various amounts of capacity shut down during the year.

MAJOR PRODUCERS

Borden, Celanese, Du Pont, Georgia-Pacific, Reichhold Chemicals

HOW MADE

Catalytic oxidation of methanol

MAJOR DERIVATIVES (U.S.)

Urea-formaldehyde resins 25%, phenol-formaldehyde resins 20%, polyacetal resins 5%, butanediol 5%

MAJOR END USES (U.S.)

Adhesives 60%, plastics 15%

FOREIGN TRADE

Exports and imports negligible

PRICES

List prices about 9 cents per lb; merchant volume about 30% of production

As might be expected for a product with substantial overcapacity, a shake-out of formaldehyde capacity probably will continue in 1985. More small plants likely will be closed this year as others operate only part time. Many small plants produce formaldehyde for resins containing either urea or phenol as comonomers. These will be hard hit. However, plants making formaldehyde for other resins and chemicals will run most of the year because of stabler markets.

Nevertheless, formaldehyde will continue to have much excess capacity. Some 8.5 billion lb of capacity, calculated on the basis of a 37% formaldehyde solution, are available for operation in 1985, this after elimination of about 10% of total capacity available as this decade began. The current capacity estimate includes some new plants that were added or some expansions that were completed early in the 1980s, partially offsetting plant shut-downs and scrappage.

In contrast to methanol, formaldehyde plants are relatively widespread and include a large number of small plants, some of which produce entirely for captive uses as do many of the larger plants. Because formaldehyde is expensive to ship—which accounts for the existence of very little foreign trade in the material—small plants are built to serve specific areas, especially if they are to make formaldehyde for use in adhesive resins for particle board and plywood. These plants are located close to mills making these wood products, which, in turn, are located near suitable timber lands. The shifting of wood-product production and the changes in demand for these products, as housing and other construction varies, account for much of the variation in formaldehyde capacity and production.

Formaldehyde plants are relatively easy to operate and to start up and shut down. Inventories as a result usually are low. Prices also vary widely because of the segmented nature of

production. High transportation costs limit shipment to an area of high temporary demand, causing prices in some locations to be considerably higher than in others.

As a result, variations in formaldehyde production can be frequent, large, and dependent on end-product demand. The end-product demand, particularly for making adhesive resins, likely will be down some in 1985 as a result of lower housing starts and less commercial building. Because these areas of construction are heavily dependent on interest rates for loans, forecasts for housing for 1985 range widely and include numerous qualifications concerning expectations for budget deficits and other factors that affect interest rates.

Formaldehyde production this year likely will be about 5.5 billion lb, as 37% solution, down 3% from 1984. This assumes that nothing significant will happen in 1985 concerning the safety of formaldehyde use. Studies continue on toxicity of formaldehyde. Results are forthcoming soon, and decisions on whether to regulate formaldehyde in various situations could be made in 1985 but probably will have no effect on 1985 production and consumption.

During 1985, no important changes are expected in formaldehyde uses. The resins going into adhesives and plastics will continue to amount to more than 60% of demand, even with some decline in the biggest uses in wood products. Most of the rest of formaldehyde demand is for use as a chemical intermediate in making many different final products. None of these other uses are large or growing fast enough to change the end-use pattern much in the 1980s.

Thus, formaldehyde in 1985 will have a year that might be characterized as average, with production holding about level with last year but down 15% from the 1979 peak of 6.5 billion lb. It may be a long time before this record is surpassed.

Reinforced plastics growth to slacken in 1985

After two very good years of recovery and growth for reinforced plastics, growth of shipments for the industry will slow down considerably this year, according to producers. In fact, the 1985 growth rate will be less than half its 1984 rate.

But even with the slower growth, shipments of reinforced plastics will set a record this year, just as they did in 1984.

A year ago producers were saying that reinforced plastics demand in 1984 would be about 12% above 1983 levels. They turned out to be right on target. Shipments in 1984 increased exactly 12% from the year before to 2.15 billion lb, just a little higher than in the glory years of the late 1970s. The average annual growth rate in the years from 1979 to 1984 was just 1%—good enough to give the industry record shipments, but not very good from a product economics standpoint. The 10-year average annual rate of growth for reinforced plastics between 1974 and 1984 was about 5%, with most of that coming in the first part of the period. In the strong recovery year of 1983, reinforced plastics shipments increased 26% over the year before.

The forecast for this year of a 5.4% increase to 2.27 billion lb will alter those historic growth figures, especially the growth rate for the shorter 1979-84 period. This will increase the five-year growth rate to an annual average of 6% since 1980, which admittedly was a poor year for reinforced plastics shipments, and it will raise the average

annual rate for the 10-year period to almost 7%.

These data were reported last week to the annual meeting of the Reinforced Plastics/Composites Institute of the Society of the Plastics Industry in Atlanta. They are part of the yearly survey of producers and others in the industry prepared by Laura Morrison of the New York City-based public relations firm of Morrison/Gottlieb.

According to the survey, the major increase in reinforced plastics demand in 1984 was for land transportation, the largest market for reinforced plastics, which increased 18% from 1983 to 540 million lb. For 1985, however, growth in that area is expected to slow considerably to 5.6%, bringing demand to 570 million lb this year.

Appliances and aircraft uses each increased 16% in 1984, with appliance demand for reinforced plastics rising to 123 million lb and aircraft demand increasing to 29 million lb. For this year, however, growth of appliance use of reinforced plastics is expected to drop dramatically to just 5.7% to 130 million lb. Growth for aircraft applications, long a great hope for reinforced plastics, on the other hand, is expected to continue strong with the growth rate rising to almost 21% and demand in 1985 hitting 35 million lb.

Marine demand, a big-ticket item, strong only in good economic times, increased 12% in 1984 to 309 million lb. For 1985, demand in this area is forecast to grow at a much lower 5% to 325 million lb.

Consumer goods' use of reinforced plastics increased almost 12% in 1984 to 143 million lb. In 1985, this category, in which demand is influenced by many of the consumer spending patterns that also influence appliances, is predicted to increase 4.2% to 149 million lb.

Electrical uses achieved an 11% growth rate in 1984 to 189 million lb. This is expected to increase another 9% during the current year to 205 million lb.

Two seemingly related end markets, construction and anticorrosion applications, came in with almost 8% increases in 1984 with construction rising to 430 million lb and anticorrosion demand increasing to 326 million lb. For 1985, construction uses are expected to pull demand up just 3% to 443 million lb, and anticorrosion demand is forecast to rise 5% to 326 million lb.

Although the entire reinforced plastics industry is growing at a forecast 5% rate this year, Owens-Corning is predicting better increases for the narrower glass fiber-reinforced plastic market with 12% growth this year over 1984, the same rate as in 1984.

Frank W. Como, vice president of the industrial operating division of Owens-Corning Fiberglass Corp., says: "The rapid development of new markets, the strength of existing applications, and a year of continued economic growth will provide an excellent environment for the reinforced plastics industry." Como is particularly bullish on military uses of glass fiber-reinforced plastics, where, he says, "applications have proliferated rapidly." □

Demand for reinforced plastics is forecast to grow about 5% this year

Millions of lb								Annual change			
	1985	1984	1983	1982	1981	1980	1979	1984-85 ^a	1983-84 ^a	1980-85 ^a	1979-85 ^a
Transportation, land	570	540	458	350	445	416	265	5.8%	17.9%	6.5%	8.0%
Construction	443	430	400	312	309	287	175	3.0	7.5	9.1	9.7
Anticorrosion	326	310	286	225	275	252	163	5.2	7.5	5.3	7.2
Marine	325	300	276	230	290	275	205	5.2	12.0	3.4	1.3
Electrical	205	189	170	140	178	162	82	8.5	11.2	4.8	9.6
Consumer goods	149	143	126	84	110	103	64	4.2	11.7	7.7	8.8
Appliances	130	123	106	82	112	104	64	5.7	16.0	4.6	7.3
Aircraft	35	29	25	22	28	25	24	20.7	16.0	7.0	3.8
Other	86	80	72	64	74	70	53	7.5	11.1	4.2	5.0
TOTAL	2299	2153	1923	1528	1821	1894	1175	5.4%	12.0%	6.0%	6.8%

^a Estimate. Source: SPI Reinforced Plastics/Composites Institute

Chemical earnings stagnate
in fourth quarter Page 18

PRELIMINARY PROGRAM
ACS spring meeting, Miami Beach Page 39

FEBRUARY 18, 1985

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Federal R&D Budget

Defense once again bumps
total upward Page 10

News of the Week

■ Government files court motion for approval of genetic engineering research project releasing DNA-modified bacteria. **Page 6**

■ USS Agri-Chemicals to be purchased by a group of company's managers. **Page 7**

■ NBS develops computer model of fire phenomena to be used by building and product designers and fire experts. **Page 7**

■ Union Carbide will start up its institute, W.Va., methyl isocyanate facility again in April. **Page 7**

■ EPA report indicates severe pollution problems in West Virginia's Kanawha Valley. **Page 8**

Cover: Photo by C&EN's David J. Hanson

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Business

Economic recovery for the U.S. chemical industry grinds to a halt as earnings fall 6% in fourth-quarter 1984. **Page 18**

International Business

U.K. chemical production increases; strong export performance contributes \$2.18 billion to British trade balance. **Page 23**

Science

Workings of coenzyme B₁₂ becoming clearer as researchers unravel enzymic reactions; low-cost concurrent computer systems introduced; AIDS virus nucleotide sequence reported; correlation discovered between antigenic markers and brain damage to children after shots against whooping cough. **Page 28**

Technology

Monsanto offers Prism membrane gas separators for dehydration of air and other streams in the vapor phase. **Page 35**

Books

"The Central Science," edited by George Kauffman and H. Harry Szmant, describes chemistry uses for high schoolers. **Page 36**

Preliminary Program

Miami Beach to host 189th ACS National Meeting in April; 463 technical sessions cover variety of topics. **Page 39**



News Focus

President Reagan's R&D budget proposal for fiscal 1986 is heavy on defense, light in other areas. **Page 10**

Funds for R&D Are Up 13% in Administration's Budget Proposal

The proposed increase of \$7 billion for defense accounts for the entire rise in federal R&D spending for fiscal 1986; nondefense R&D would suffer a net loss

Janice R. Long and David J. Hanson, C&EN Washington

The fiscal 1986 R&D budget is more frost bitten than frozen in the proposal President Reagan sent to Capitol Hill earlier this month. Total R&D funding is up 13% to \$57.6 billion in a total proposed budget that is up only 1% to \$938 billion.

However, there is an element of smoke and mirrors in this fiscal 1986 R&D budget. As is the case in the total budget, the 22% or \$7.1 billion increase set for defense R&D spending is greater than the overall \$6.6 billion increase in total R&D funding. Thus, in the proposed budget, funding for nondefense R&D is actually down 3% to \$18.2 billion.

Overall funding for basic research is up 1%, or \$76 million, to \$7.9 billion. Here again the 16% or \$133 million increase slated for basic defense research is

more than the total increase. Nondefense basic research funding is down \$57 million to \$6.9 billion. Funding for R&D facilities is also down, off 7% to \$2.1 billion. Most of the decrease owes to postponing or stretching out the construction of major new facilities.

It must be obvious by now that the Department of Defense is once again the big winner in the Administration's latest R&D budget proposal. Its research, development, testing, and evaluation funding comprises more than two thirds of the entire federal commitment to research. In fact, at more than \$39 billion, it totals more than the entire federal R&D budget did in 1983. A budget this large will offer a tempting target as Congress seeks ever more ways to reduce federal spending.

As usual, most of the defense increase is devoted to development of advanced tactical weapons systems, such as the JYX aircraft and the C-17 transport aircraft. But the more basic research portion, known as the technology base, of the defense R&D budget also is slated for a 13% increase to \$3.5 billion, which will be distributed fairly evenly among the three major services and the several defense agencies.

One new initiative in the fiscal 1986 budget is aimed at strengthening DOD's ties with universities. About \$25 million is set aside for graduate scholarships and assistantships. This is the first time DOD has offered such assistance. The funds are targeted to go to those students working on defense-related research and emerging technologies. Total support for universities in the DOD budget amounts to about \$900 million, according to defense department sources, of which up to \$500 million would support basic research. Out of these basic research funds, DOD estimates about \$76.6 million will go directly to basic research in chemistry. This is a 9% increase from fiscal 1985 support of about \$70 million.

Among the defense agencies, the most significant budget increase is for the Strategic Defense Initiative,

Glossary of budget terms

Fiscal year. Year running from Oct. 1 to Sept. 30. The fiscal year is designated by the calendar year in which it ends.

Obligations. Commitments made by federal agencies to pay out money for products, services, or other purposes, as distinct from the actual payment.

Outlays. Payments for obligations incurred under Congressionally granted budget authority generally made by issuance of checks on the Treasury. Outlays during any fiscal year may be for obligations incurred in prior fiscal years or in the same fiscal year.

Reconciliation. Enacted legislation canceling budget authority previously granted by Congress. Reconciliations proposed by the President must be approved by Congress within 45 days to become effective.

Note: The R&D numbers obtained from individual agencies frequently differ from those used by the Office of Management & Budget in preparing its analysis of total federal R&D funding.

the so-called Star Wars program. Funding for this program is slated to increase 166% over fiscal 1985 to \$3.7 billion. Of this huge amount, about \$1.4 billion would go for surveillance, tracking, and other data assessments, and more than \$1.8 billion for development of directed energy and kinetic energy weapons.

In contrast to DOD, the budget of the second largest supporter of R&D—the Department of Health & Human Services—would fall 6% to \$4.8 billion. Within that amount, the budget for the National Institutes of Health would decline 5% to \$4.4 billion.

The smoke and mirrors trick is nowhere more evident than in NIH's budget proposal. Even though the budget has been cut, Administration officials maintain that it will allow NIH to continue its normal practice of funding 5000 or so new and competitive research grants and providing support for 500 research centers around the country. Once awarded, the grants usually are supported for three years, with funding being provided annually. NIH has asked for \$3.6 billion to support these activities in fiscal 1986, the same amount it requested in fiscal 1985.

However, Congress, in setting final fiscal 1985 budget totals, added \$250 million to that NIH budget request. The money was to be used to increase from 5000 to 6500 the number of new grants funded. Once these 1500 additional grants were funded, NIH would have had to continue supporting them for two additional years, adding to its budget total—something that would have been counter to the Administration's goal of cutting or at least freezing government spending.

So going directly against the wishes of Congress, and making a wide departure from usual funding procedures, NIH has decided to spend all the fiscal 1985 money Congress provided, but it is supporting only the usual number of new research grants. That number is being kept constant by providing three-

year funding for 650 of the 5000 grants and two-year funding for 45 of the research centers.

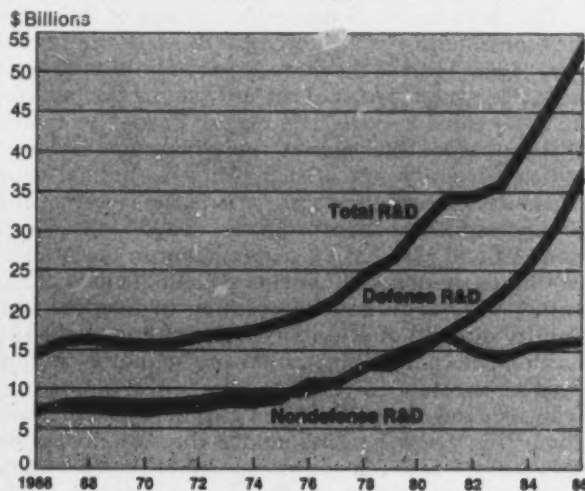
On the face of it this decision is legally correct. All the money appropriated by Congress will be used to support research grants. And NIH won't incur the future costs it would have if 1500 more grants had been funded. However, this budgetary sleight of hand is not appreciated by Congress. Rep. Henry A. Waxman (D-Calif.) already has introduced a joint resolution restating Congress' intent for NIH to fund 6500 new grants.

The third largest supporter of R&D is the Department of Energy, and in light of its proposed 13% cut in total budget to \$12.4 billion, the 6% cut in its R&D budget to \$4.6 billion may not seem too drastic. However, when one factors out the \$58 million, or 3% increase, set for weapons R&D and testing, civilian R&D funding would be down 11% to \$2.7 billion.

Even funding for DOE's supporting research and technical analyses programs, which has exhibited strong growth in other tight budget years, is scheduled to be down 4% to \$427 million. Within that category, total funding for the chemical sciences program would decrease slightly to \$94.2 million because of a 5% cut to \$5.8 million in the construction budget.

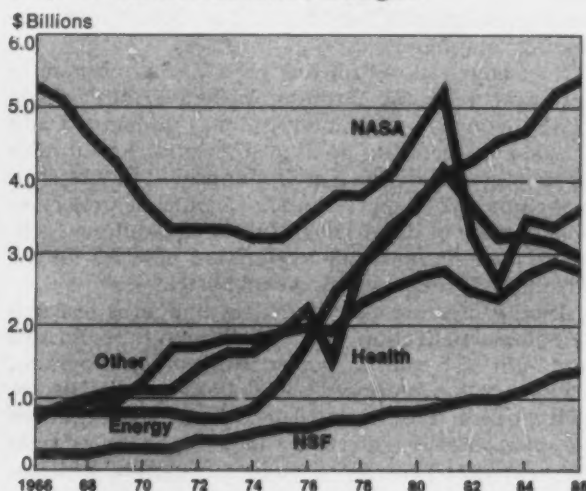
Operating expenses for the chemical sciences program will be frozen at the 1985 level of \$79.5 million, necessitating some selective termination of projects. Research areas of emphasis include photochemistry, chemical physics, atomic physics, the basic chemistry of coal, catalytic phenomena, separations, analytical techniques, and chemical thermodynamics. Operation of both the National Synchrotron Light Source facility and the Combustion Research Facility would be funded at the same level as in 1985. About \$6.7 million of the capital equipment budget, frozen at \$8.8 million, will go to meet the continuing need of scientists for state-of-the-art instrumentation, according to DOE budget books.

Twenty years ago defense accounted for 48% of R&D spending; now it's 70%...



Source: Office of Management & Budget

... and health has gone from 10% to 34% of the nondefense budget



DOE's budget for materials sciences would decline 5% to \$183 million, owing to a 33% cut to \$29.0 million in the construction budget. However, even though drastically reduced, the budget will provide \$17.4 million for a new surface science and catalysis laboratory and an advanced materials laboratory at Lawrence Berkeley Laboratory's Center for Advanced Materials Research.

The operating expenses budget for materials sciences actually would increase 4% to \$139 million. Priority research areas in 1986 include synthesis, alloying, preparation of new materials and structures, and materials characterization and property measurements using highly advanced techniques.

Funding for another part of the supporting research and technical analysis program, university research support, would drop 13% to \$9.7 million. Funding for university research instrumentation would be down 1% to \$4.5 million.

Sliding very steeply is DOE's fossil energy R&D funding, down 30% to \$243 million. Within that program, funding for coal R&D, which includes a fair amount of chemical research, would decrease even more—41% to \$149 million. However, funding for university coal research would rise 33% to \$5.9 million, allowing for the awarding of 30 research grants in fiscal 1986, up from 20 in the current year.

Some other agencies fare much better in Reagan's budget proposal. For instance, for the National Aeronautics & Space Administration, the President has requested \$7.9 billion, of which almost \$3 billion is slated for R&D. One of the biggest items in this request is \$230 million for continuing development of the space station. NASA Administrator James M. Beggs says that this is about \$50 million less than the agency had sought for the station, but it is more than the \$150 million being spent this year. Other programs at NASA scheduled for increases include space transportation development and research on planetary exploration and space applications. Research funding on physics and astronomy would decrease about \$47 million in fiscal 1986 as some programs, such as the Hubble space telescope and the Gamma Ray Observatory, are nearing completion.

The budget allows for one new NASA program to start next year, the Orbiting Maneuvering Vehicle (OMV), which is a remotely piloted unmanned and reusable spacecraft to be used to extend the shuttle's capabilities. Beggs says that the funds will be stretched to include two Congressionally mandated projects—development of the Advanced Communications Technology Satellite and the acceleration of work on the Advanced Turboprop Propulsion System.

Another new item in the NASA budget is research for commercialization of space. Although begun this year with \$8.5 million pooled from other programs, the agency has proposed \$30 million specifically for such work in 1986. Related to this are the flights of the space shuttle, which may have to be reduced over the next year because of budget restraints and less than anticipated use by the military. Commercial use of the shuttle is progressing as expected, Beggs says.

The news is also good at the National Science Foundation, where the total budget would be up 7% to \$1.6 billion. NSF's research budget also would rise 7%, to \$1.4 billion. In addition, the chemistry division's budget would be up 7% to \$93.5 million. However, the number of senior investigators supported is remaining constant at about 875 so that average grant size can be maintained close to this year's level.

Cutting across all of the research directorates, funding for research instrumentation is scheduled to be up 13% to \$271 million, with funding for research equipment by the mathematical and physical sciences directorate up 15% to \$102 million. The college science instrumentation program will provide matching funds of \$5 million for the acquisition of equipment by four-year colleges.

Support for faculty research at predominantly undergraduate institutions would rise 5% to \$44 million. Support for graduate students on research awards would rise 9% to \$111 million, allowing support of an additional 445 graduate students, which brings the total to about 11,140. Support for graduate research fellowships, however, is set to remain constant at \$27.3 million, whereas support for postdoctoral research will increase 7% to \$61.2 million.

NSF is reorganizing its engineering directorate, it says, to achieve a better balance between established engineering disciplines and those just emerging and to create stronger links between academic engineering and industry. Overall proposed funding for the engineering directorate is up 13% to \$170 million. Support for engineering research centers will rise 150% to \$25 million. But funding for chemical, biochemical, and thermal engineering is being held constant at \$29.3 million.

It appears that support for science and engineering education would be held constant at \$82 million in fiscal 1986. However, NSF intends to spend only \$51 million of the \$82 million education budget this year, leaving \$31 million available for spending in fiscal 1986. Thus, it will actually ask Congress for only \$51 million in new spending authority for fiscal 1986.

The Department of Agriculture is one of the agencies contributing to the downside of R&D funding for fiscal 1986. Most of the more than \$57 million drop in its total research proposal comes from the Cooperative State Research Service. The biggest change would be elimination of the special research grant category, which currently funds such things as animal drug clearance, pesticide impacts, germ plasm research, and acid precipitation. This program funded at \$28.5 million in fiscal 1985 has been zeroed out in the Administration's proposal. Other cuts at CSRS include elimination of \$5.8 million for research in livestock and poultry diseases at veterinary colleges, and about \$5.8 million for competitive grants and higher education programs at state universities.

In 1986 the Agricultural Research Service would get about this year's funding, which the Administration says will allow for an additional \$5.5 million for high-priority research projects. This is to become available from an equivalent amount of decreased spending

TOTAL FEDERAL R&D BUDGET PROPOSAL

	1985	1986	1987	1988	1989	1990
Energy	1,200	1,200	1,200	1,200	1,200	1,200
Health	1,200	1,200	1,200	1,200	1,200	1,200
Environment	1,200	1,200	1,200	1,200	1,200	1,200
Space	1,200	1,200	1,200	1,200	1,200	1,200
Other	1,200	1,200	1,200	1,200	1,200	1,200
TOTAL	5,000	5,000	5,000	5,000	5,000	5,000

Energy Research Funding by Agency (%)

	1985	1986	1987	1988	1989	1990
DOE	100	100	100	100	100	100
NSF	10	10	10	10	10	10
NIH	10	10	10	10	10	10
NASA	10	10	10	10	10	10
Environmental	10	10	10	10	10	10
Health	10	10	10	10	10	10
Other	10	10	10	10	10	10
TOTAL	100	100	100	100	100	100

Energy R&D Funding by Agency (%)

	1985	1986	1987	1988	1989	1990
DOE	100	100	100	100	100	100
NSF	10	10	10	10	10	10
NIH	10	10	10	10	10	10
NASA	10	10	10	10	10	10
Environmental	10	10	10	10	10	10
Health	10	10	10	10	10	10
Other	10	10	10	10	10	10
TOTAL	100	100	100	100	100	100

from "management savings and changes in pay scales," according to USDA estimates.

The ARS is the target of one of the many fiscal 1985 rescission proposals being sent to Congress along with fiscal 1986 budget proposals. The Administration wants to take \$37.9 million out of the current year's budget. Congress had appropriated the funds for planning, design, and construction of a number of new research laboratories which the Administration says aren't needed because ARS's research facility system has been operating well below its capacity for years.

The facilities the Administration doesn't want built include: south central small farms research center, national soil tilth center, germ plasm collection facility, metabolism and radiation research laboratory, south central agricultural research laboratory, plant stress and soil moisture laboratory, and the forage seed production and research center.

At the Forest Service, a cut of \$15.8 million has been proposed for its in-house research, which USDA says will be spread throughout its programs. Even so, about 60 scientist positions will have to be eliminated.

Although it is pointed to as a shining example of the Administration's support for both research and the environment, the EPA R&D budget is still relatively small. With a proposed \$19.4 million increase, the total R&D budget would become \$325 million for fiscal 1986. According to the organization Environmental Safety, which has been a severe critic of the Reagan Administration's funding for EPA, this gives the R&D office less spending power than it had in 1972.

Still, the 6% proposed rise is a slight improvement. The greatest change is for research on toxic substances, which will get \$11.8 million more for 1986, to be used to develop environment risk assessment methodologies and to initiate research in epidemiology and reproductive toxicology. EPA says it will try to gather new information in hopes of regulating, not banning, chemicals already being used.

Also, for the first time in a number of years, energy R&D at EPA is the largest area of research. This is directly attributable to a huge increase in acid rain research, funding for which would rise to \$60.5 million from \$22.9 million this year. The big-ticket energy research item in the past, synthetic fuels, is being phased out. Only some health effects work remains, and this will be completed in 1985.

A large cut in EPA's proposed research funding occurs in the interdisciplinary category. This is being accomplished by making about a \$7.6 million decrease in funding for exploratory research grants and in the number of university-based centers of excellence. Other decreases are proposed for air, drinking water, radiation, and management. Most of these reductions are said to result from completion of regulatory projects for which funds are no longer needed.

Decimated may be the best way to describe the Department of Commerce's proposed research budget. It's down 30% to \$271 million. The National Bureau of Standards' budget would decline 14% to \$108 million. According to NBS director Ernest Ambler,

HOW THE AGENCIES FARE

Research at NASA up handsomely

\$ Millions	1988 ^a	1989 ^b	1990 ^b	% change 1988-90
Conduct of R&D	\$2870.7	\$2421.8	\$2077.1	19%
Physics and astronomy	830.4	677.2	567.6	-7
Space applications	551.8	374.1	314.0	48
Space transportation systems	459.3	351.4	431.7	31
Planetary exploration	350.0	290.9	217.4	23
Aeronautical research	354.0	342.4	315.3	3
Space station	230.0	150.0	21.9 ^c	53
Space research & technology	168.0	150.0	137.0	12
Life sciences	72.0	62.3	58.0	18
Commercial use of space	30.0	8.5 ^c	—	253
Tracking & data acquisition	16.2	14.8	14.2	9
R&D facilities	149.3	150.0	155.5	0
TOTAL	\$3020.0	\$2771.8	\$2232.6	17%

a Estimate. b Actual. c Start-up funds originally from other categories. Source: National Aeronautics & Space Administration

Research at DOE drops 6%

\$ Millions	1988 ^a	1989 ^b	1990 ^b	% change 1988-90
Defense R&D, testing	\$1865.3	\$1810.1	\$1386.1	3%
Energy supply R&D	1698.8	1833.2	2059.9	-9
Supporting research and technical analysis	425.6	446.9	342.4	-4
Magnetic fusion	390.0	434.0	469.1	-10
Nuclear fusion	371.8	416.3	697.7	-11
Environment	228.3	230.9	229.4	-1
Solar and other renewables	175.6	211.8	218.8	-17
Other	77.3	93.3	102.5	-17
General science and research	985.4	728.3	834.6	-8
Fossil R&D	242.7	347.1	342.4	-30
Conservation R&D	145.1	176.0	176.6	-18
TOTAL	\$4611.0	\$4894.7	\$4593.6	-6%

a Estimate. b Actual. Source: Department of Energy, Office of Management & Budget

EPA's R&D funds continue to climb

\$ Millions	1988 ^a	1989 ^a	1990 ^b	% change 1988-90
Energy/acid rain	\$ 67.2	\$ 58.1	\$ 37.4	16%
Air	65.4	67.1	57.9	-3
Hazardous wastes	49.6	41.1	34.1	21
Toxic substances	37.7	25.9	23.0	46
Water quality	28.2	27.3	25.2	3
Drinking water	23.9	24.7	22.4	-3
Interdisciplinary	18.7	26.4	22.6	-29
Superfund	13.1	12.7	10.2	3
Pesticides	12.3	10.2	6.0	21
Program management	8.4	9.7	8.9	-13
Radiation	0.2	2.1	1.7	-90
TOTAL	\$324.7	\$305.3	\$249.4	6%

a Estimate. b Actual. Note: Obligations. Source: Environmental Protection Agency

Defense RDT&E again scores big gains

\$ Millions	1988 ^a	1989 ^b	1990 ^b	% change 1988-90
Tactical programs	\$12,395.2	\$ 9,493.2	\$ 7,929.3	31%
Strategic programs	8,555.8	8,359.0	7,877.7	2
Advanced technology development	5,461.3	2,765.8	1,352.2	97
Intelligence & communications	5,031.1	3,956.6	3,406.0	27
Defensewide mission support	4,311.8	3,751.2	3,318.2	21
Technology base	3,525.1	3,121.0	3,055.1	13
TOTAL	\$39,280.1	\$31,451.8	\$26,938.5	25%

a Estimate. b Actual. Source: Office of Management & Budget

Agriculture is a big loser in 1986

\$ Millions	1988 ^a	1989 ^a	1990 ^b	% change 1988-90
Agricultural Research Service	\$487.3	\$487.7	\$489.0	0%
Cooperative State Research Service	251.2	291.9	255.5	-14
Forest Service research	104.2	120.0	109.4	-13
National Agricultural Library	11.1	11.4	10.4	-3
TOTAL	\$853.8	\$911.0	\$864.3	-6%

a Estimate. b Actual. Source: Department of Agriculture

NIH funding drops for first time

\$ Millions	1988 ^a	1989 ^a	1990 ^b	% change 1988-90
National Institutes	\$4474.4	\$4717.9	\$4022.3	-5%
Cancer	1126.0	\$1183.8	1081.6	-5
Heart, Lung & Blood	775.2	805.3	704.9	-4
Arthritis, Diabetes & Digestive & Kidney Diseases	519.9	543.6	464.0	-4
General Medical Sciences	458.5	482.3	415.9	-5
Neurological & Communicative Disorders & Stroke	373.9	396.9	335.9	-6
Allergy & Infectious Diseases	352.6	371.0	319.6	-5
Child Health & Human Development	293.1	313.3	276.0	-6
Environmental Health Sciences	182.6	194.8	180.8	-8
Eye	164.4	181.7	155.1	-10
Aging	134.6	144.5	115.3	-7
Dental research	93.4	100.7	88.7	-7
Research resources	263.0	304.0	243.2	-13
National Library of Medicine	53.3	55.9	49.6	-5
Research facilities	14.9	21.7	25.0	-31
John E. Fogarty Center	11.4	11.7	11.3	-3
TOTAL	\$4817.0	\$5111.2	\$4351.4	-6%

a Estimate. b Actual. Source: Office of Management & Budget

NSF budget would be up 7% . . .

\$ Millions	1988 ^a	1989 ^a	1990 ^b	% change 1988-90
Mathematical and physical sciences	\$ 428.9	\$ 396.6	\$ 355.0	8%
Astronomical, atmospheric, earth, and ocean sciences	372.2	351.7	326.6	6
Biological, behavioral, and social sciences	272.0	252.0	223.4	8
Engineering	170.1	150.0	128.6	13
Antarctic program	120.1	110.8	102.4	8
Science and engineering education	82.0	82.0	57.7	0
Program development and management	69.9	70.7	66.2	-1
Advanced scientific computing	46.2	41.5	6.0	11
Scientific, technological, and international affairs	38.4	44.5	36.2	-14
Special foreign currency	1.0	2.6	2.9	-64
TOTAL	\$1800.6	\$1502.6	\$1308.7	7%

a Estimate. b Actual. Note: Obligations. Source: National Science Foundation

"This proposed budget is the result of the Administration's careful evaluation of the bureau's programs and priorities. It reflects the minimum resources we need."

But even this minimal budget allows for some increases. For example, NBS would get \$8 million for a cold neutron source facility for measuring the properties, performance, and processing of high-technology materials. Other proposed funds include \$3.5 million for development of key measurements and data pertaining to the use and manufacture of advanced ceramics, \$3.0 million for development of measurements and standards for biotechnology, and \$1.9 million for process and quality control measurements.

However, if there are increases, there must be decreases in a budget that is down overall. Once again the Administration is calling for elimination of the Center for Building Technology and the Center for Fire Research for savings of \$8.2 million. The automated data standards development and testing program would be cut in half to \$5 million, and \$3.3 million comes out of NBS's equipment replacement program.

For Commerce's other major research agency, the National Oceanic & Atmospheric Administration, the budget will be cut sharply. Not only would NOAA's operations, research, and facilities budget be down 20% to \$933 million in fiscal 1986, it may also lose some of its fiscal 1985 funding as well.

The Administration is requesting a rescission of \$104 million in the current budget that already has been approved by Congress. It wants to eliminate the Sea Grant program (\$19.5 million), ocean service centers (\$4.9 million), the second polar satellite (\$38.8 million), and coastal zone management grants (\$37 million).

If Congress doesn't approve the rescission in the fiscal 1985 budget, the Administration will try to eliminate these programs again in the fiscal 1986 budget. It wants to cut NOAA's ocean and coastal programs budget 57% to \$92 million. Also scheduled for elimination are the underseas research program and the Great Lakes environmental research laboratory.

The Tennessee Valley Authority is not one of the largest supporters of federal R&D projects, but it is very big in fertilizer development. Its national fertilizer development center in Muscle Shoals, Ala., is active in both fertilizer R&D and introduction. That may no longer be the case in the near future. The fiscal 1986 budget proposal calls for cutting the budget for these activities 85% to \$10 million.

Of course, Congress has yet to work its will on the proposed budget. The Administration has the first but not the last say on what will be spent in any fiscal year. The pattern in the past few years, with the exception of the DOD research budget—which usually gets trimmed—has been for Congress to accept the Administration's budget proposals for increases in R&D funding, and to beef up funding for items in which large cuts have been proposed. That pattern may not hold true this year, when everyone is expressing deep concern about the federal deficit. □

Chemical Earnings Slipped in Fourth Quarter

William J. Storck, C&EN New York

The economic recovery ended for the U.S. chemical industry in the fourth quarter of 1984 after lasting essentially about a year and a half. Sales for the industry were unchanged from fourth-quarter 1983, and earnings fell 6%. This caused profit margins to slip to their lowest levels in more than 12 months—a performance picture that carried through to the oil companies and to many diversified firms producing chemicals. The question now is whether the chemical industry will

remain soft, or find some spark to kindle new growth.

Another sign that the industry is slowing is the number of companies with falling earnings. In the third quarter, in which earnings increased an average of 14% for 30 basic chemical firms surveyed by C&EN, seven companies had declining earnings and all of them registered higher sales. But in the fourth quarter, the number of companies with declining income almost doubled to 13 (out of a sample of 28 reporting at press time) and eight firms had lower sales.

By this time in the chemical recovery many of the cost-cutting measures, such as employment reductions and streamlining of plants instituted by the industry, have been exploited to their limits. And now costs are rising. Prices, which normally would offset the increased costs, are not keeping pace, and production is becoming stagnant. In the fourth quarter, according to government data, prices for chemicals and allied products averaged only 1.6% above the same period in 1983, and production chalked up its lowest annual increase—about 2.4%—since

Chemical industry leaders for fourth-quarter. . .

Sales			Earnings ^a			Profitability		
Rank	\$ Millions	Rank 1983	Rank	\$ Millions	Rank 1983	Earnings as % of sales	Rank 1983	
1 Dow Chemical	\$2687.0	1	1 PPG Industries	\$80.4	3	1 Freeport-McMoRan	12.8%	2
2 Union Carbide	2380.0	2	2 Dow Chemical	64.0	1	2 International Flavors	12.0	1
3 W. R. Grace	1830.8	3	3 W. R. Grace	59.1	5	3 Nalco Chemical	10.3	4
4 Monsanto	1559.0	4	4 Union Carbide	57.8	4	4 Ethyl	9.9	6
5 PPG Industries	1057.0	5	5 American Cyanamid	50.8	6	5 Loctite	9.4	3
6 American Cyanamid	976.0	6	6 Hercules	44.1	11	6 Petrolite	9.4	8
7 Celanese	825.0	7	7 Monsanto	41.0	2	7 PPG Industries	7.6	7
8 Hercules	617.4	8	8 Ethyl	38.5	9	8 Air Products	7.4	5
9 National Distillers	582.2	9	9 Air Products	32.1	8	9 First Mississippi	7.3	22
10 Olin	496.0	10	10 Celanese	32.0	7	10 Hercules	7.1	18

. . . and for full-year 1984

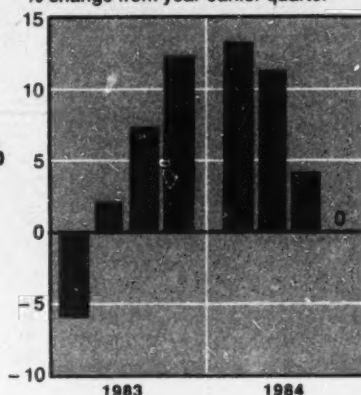
Sales			Earnings ^a			Profitability		
Rank	\$ Millions	Rank 1983	Rank	\$ Millions	Rank 1983	Earnings as % of sales	Rank 1983	
1 Dow Chemical	\$11,418.0	1	1 Dow Chemical	\$549.0	2	1 International Flavors	14.5	1
2 Union Carbide	9,500.0	2	2 Monsanto	439.0	1	2 Freeport-McMoRan	11.7	2
3 W. R. Grace	6,727.8	4	3 Union Carbide	374.7	3	3 Nalco Chemical	11.0	3
4 Monsanto	6,691.0	3	4 PPG Industries	317.3	4	4 Loctite	10.6	4
5 PPG Industries	4,200.0	5	5 American Cyanamid	215.9	5	5 Petrolite	8.8	6
6 American Cyanamid	3,856.7	6	6 Hercules	197.2	6	6 Rohm & Haas	8.4	7
7 Celanese	3,328.0	7	7 W. R. Grace	192.6	7	7 Air Products	7.9	8
8 Hercules	2,571.0	8	8 Rohm & Haas	172.2	8	7 Ethyl	7.9	12
9 National Distillers	2,244.9	9	9 Celanese	161.0	10	9 Hercules	7.7	13
10 Olin	2,065.3	10	10 Air Products	138.6	9	10 PPG Industries	7.6	9

^a After taxes. Note: Based on 30 companies listed on page 20.

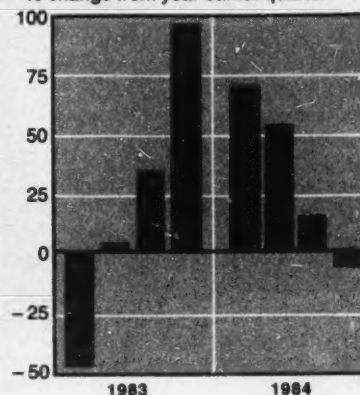
Chemical industry 1984 fourth-quarter results

- Sales were flat
- Earnings declined 6%
- Profit margins fell to 4.2%
- Production rose only 2%
- Prices were up 2%

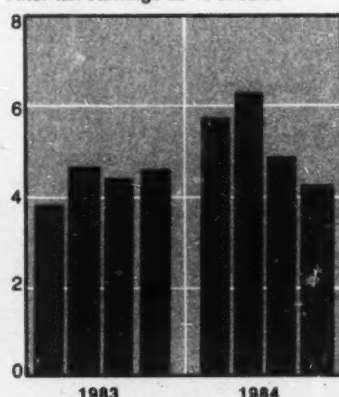
Sales
% change from year-earlier quarter



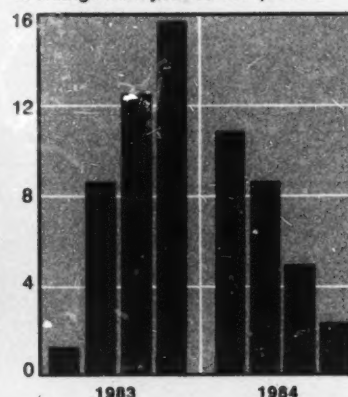
Earnings
% change from year-earlier quarter



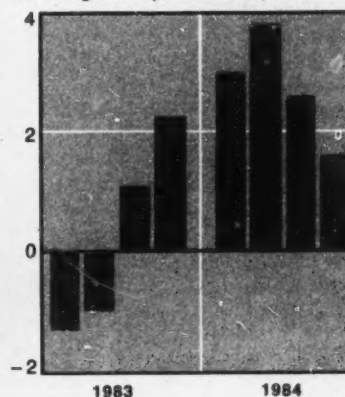
Profit margins
After-tax earnings as % of sales



Production
% change from year-earlier quarter

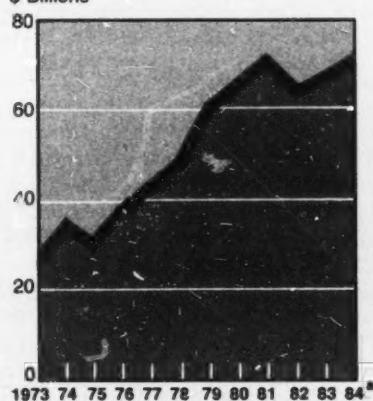


Prices
% change from year-earlier quarter

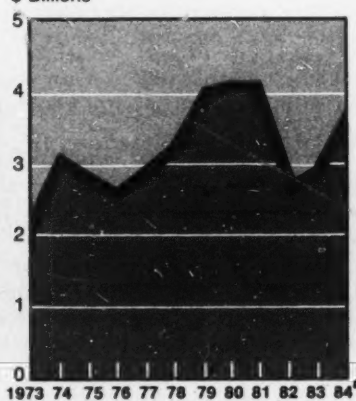


Sales for 1984 were up 7%, and earnings climbed 29% to raise profitability to 5.3%

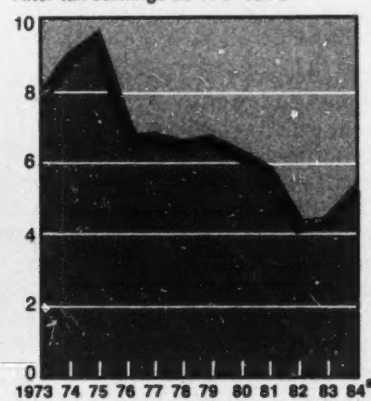
Annual sales
\$ Billions



Annual earnings
\$ Billions



Annual profit margins
After-tax earnings as % of sales



* Preliminary. Note: All sales, earnings, and profit-margin data are based on the combined results of the 30 companies listed on page 20.

Average earnings for largest chemical companies fell 9% in fourth quarter

	FOURTH-QUARTER 1984						FULL-YEAR 1984					
	Sales	Earnings ^a	Change from 1983		Profit margin ^b		Sales	Earnings ^a	Change from 1983		Profit margin ^b	
	(\$ millions)		Sales	Earnings ^a	1984	1983	(\$ millions)		Sales	Earnings ^a	1984	1983
Air Products	\$ 435.5	\$ 32.1	5%	-5%	7.1%	6.2%	\$ 1,754.7	\$ 138.6	8%	21%	7.9%	6.9%
American Cyanamid	978.0	50.8	6	-6	5.2	6.0	3,858.7	215.9	9	30	5.6	4.7
Colson	625.0	32.0	-3	-38	3.3	6.1	3,328.0	101.0	2	44	4.8	3.4
Chemtec	89.9	3.5	15	-14	3.5	5.1	346.1	20.1	26	16	5.8	6.4
Crompton & Knowles	52.6	2.0	-11	15	3.3	2.9	230.4	7.9	0	25	3.3	2.7
Dow Chemical	2,687.0	64.0	-8	-23	2.4	2.9	11,418.0	549.0	4	57	4.8	2.7
Eastman Chemical	na	na	na	na	na	0.2	na	na	na	na	na	1.9
Ethyl	387.2	38.5	-14	19	9.9	7.2	1,675.1	132.2	-4	25	7.9	6.1
First Mississippi	64.3	4.7	13	149	7.3	3.5	288.1	7.1	29	87	2.5	1.7
Frederick & Nicollet	216.3	27.6	8	21	12.8	11.4	842.2	98.4	7	9	11.7	11.5
H. B. Fuller	111.6	3.5	4	-18	3.1	3.8	448.0	13.0	8	-4	2.9	3.3
W. R. Grace	1,830.8	59.1	4	2	3.2	3.3	6,727.8	192.6	8	34	2.9	2.3
Hercules	617.4	44.1	-3	61	7.1	4.3	2,571.0	197.2	-2	31	7.7	5.7
International Flavors	103.8	12.4	8	8	12.0	11.9	476.7	69.2	3	1	14.5	14.8
International Minerals	377.2	20.5	7	-5	5.4	6.1	1,607.0	95.0	8	13	6.0	5.7
Loctite	58.3	5.5	3	-8	9.4	10.6	243.8	25.8	7	16	10.6	9.7
Lubrizol	na	na	na	na	na	6.4	na	na	na	na	na	8.2
Monsanto	1,559.0	41.0	-6	-47	2.6	4.7	6,691.0	439.0	6	13	6.6	6.2
Morton-Thiokol	449.6	29.4	11	23	6.5	5.9	1,953.4	114.4	14	23	5.9	5.4
Nalco Chemical	166.5	17.1	6	7	10.3	10.2	664.3	73.1	8	12	11.0	10.7
National Distillers	582.2	11.7	5	-54	2.0	4.6	2,244.9	89.9	15	11	3.1	3.2
Olin	496.0	12.2	2	0	2.5	2.5	2,065.3	88.7	7	24	4.3	3.7
Pennwalt	259.0	16.8	6	def	6.5	def	1,047.2	50.4	7	118	4.8	2.4
Petrolite	75.3	7.1	5	46	9.4	6.8	294.1	25.8	2	17	8.8	7.7
PPG Industries	1,057.0	80.4	10	18	7.6	7.0	4,200.0	317.3	14	30	7.6	6.6
Reichhold Chemicals	177.1	5.9	-1	9	3.3	3.0	801.4	25.7	7	18	3.2	2.9
Rohm & Haas	454.5	25.2	5	-12	5.5	6.6	2,042.0	172.2	9	25	8.4	7.3
Stauffer Chemical	327.6	-3.2	-13	def	def	4.3	1,448.3	-0.5	10	def	def	def
Union Carbide	2,380.0	57.8	1	-2	2.4	2.5	9,500.0	374.7	6	50	3.9	2.8
Wilco Chemical	371.7	14.5	3	-4	3.9	4.2	1,495.8	58.7	8	13	3.9	3.8
Total 15 largest firms	\$15,114.3	\$588.3	0%	-9%	4.0%	4.4%	\$61,634.8	\$3,256.7	6%	35%	5.3%	4.2%
Total next 13 firms	\$ 2,074.3	\$117.5	1%	11%	5.7%	5.2%	\$ 8,826.4	\$ 474.7	9%	24%	5.5%	4.8%
GRAND TOTAL	\$17,188.6	\$716.3	0%	-6%	4.2%	4.4%	\$70,261.3	\$3,733.4	7%	33%	5.5%	4.3%

^a Earnings from continuing operations excluding major nonrecurring and extraordinary items. ^b Earnings as a percentage of sales. na = not available at press time; def = deficit.

the first quarter of 1983 as demand softened and companies worked off inventories.

Dow president and chief executive officer Paul F. Orefice comments, "We did not see a normal seasonal increase in demand for chemical products during the fourth quarter. Therefore, we felt it was necessary to reduce inventories through lower operating rates." Du Pont's chairman Edward G. Jefferson states, "Fourth-quarter results were lower than anticipated, primarily because of some weakness in the industrial sector of the economy, which resulted in lower de-

mand and price erosion for many of our industrial and specialty businesses."

One of the major problems for production—and pricing for that matter—has been foreign trade. The strength of the dollar against foreign currencies has been making U.S. exports expensive in relation to foreign goods, holding down exports. And the reverse situation has increased imports of chemicals into the U.S., enabling them to compete effectively with U.S.-produced chemicals.

According to government figures, chemical exports in the fourth quar-

ter increased 9% over the same period the year before. But imports rose almost twice as fast, jumping nearly 18% during the final three months of the year. This drove down the chemical trade surplus in the fourth quarter, which dropped 4% from fourth-quarter 1983.

This isn't the whole story. Downstream products and goods that use chemicals are feeling the same pressure, if not more, from imports simply because it is more cost effective to ship higher-value-added finished products than bulk commodities.

Du Pont's Jefferson, though speaking of the full year in which the

company showed increased earnings, says, "Despite the improvement, many businesses continued to experience the adverse effects of the overvalued dollar, which has constrained volume and caused some price erosion in both domestic and international markets. Particularly hard hit was the domestic apparel fibers market, where 1984 imports of textiles and apparel increased about 34% over the 1983 level."

The result was something of a shocker for the industry. After a year-to-year doubling in the fourth quarter of 1983, annual quarterly increases in earnings for the industry have trended downward—70% in the first quarter, 52% in the second quarter, 14% in the third quarter, and now 6% in the fourth quarter.

In last year's fourth quarter, earnings for the 28 chemical companies that had reported by press time totaled \$716 million, down an average of 6% from the same period of 1983, for the poorest growth performance since the first three months of 1983. Sales for the 28 were essentially unchanged at \$17.2 billion, which is again the worst performance since the first quarter of the year before.

As a result, profit margins fell to an average of 4.2% in the final three months of 1984 from 4.4% in the same period of 1983. This is the lowest profit margin since first-quarter 1983, when it was 3.8%.

The smaller, more specialized firms in C&EN's survey lagged the larger companies in responding to the economy; this is becoming the norm. The 15 larger firms recorded an average earnings decline of 9% to a total of \$599 million on flat sales of \$15.1 billion. The 13 smaller companies that had reported, however, still managed an earnings gain of 11% to \$118 million on a 1% sales gain to \$2.07 billion. The result was that profit margins for the larger firms dropped to an average of 4.0% in the fourth quarter from 4.4% in the same period the year before. The average profit margin for the 13 smaller companies rose to 5.7% in the fourth quarter of 1984 from 5.2% a year earlier.

The weakness that became appar-

Ground rules for C&EN earnings analysis

C&EN's quarterly report on financial performance of the U.S. chemical industry contains data from the 30 largest U.S. basic chemical companies and from 36 oil and diversified companies, each with more than \$200 million in annual chemical sales.

To be included in the table of basic chemical producers, a company must have at least 40% of its sales in chemicals, and its chemical operations must be the largest single portion of the company's operations.

In referring to chemical sales, C&EN means those chemicals whose molecular composition has been changed in the course of manufacture. Hence, chemical sales include those of traditional categories of basic petrochemicals and inorganics, organic intermediates and inorganic compounds, polymers such as plastics and fibers, agricultural chemicals, and specialty derivatives.

In listing earnings, the survey gives after-tax income for continuing operations before nonrecurring items and extraordinary charges. Foreign currency translations are included.

ent in the fourth quarter actually began to surface in the previous three-month period. In the normally slow third quarter, earnings fell 27% from the second quarter, and sales were off 6%. This trend continued in the fourth quarter, with earnings dropping another 14% and sales falling 1%. Thus, unless something happens to renew growth in the industry, the second quarter of 1984 will have been the high point of the chemical recovery.

This quarter also was the high point in terms of profitability for many chemical firms, with profit margins for the 28 companies dropping to an average of 4.2% in the fourth quarter from 4.8% in the third quarter, 6.2% in the second quarter.

Again, the larger firms performed worse than the smaller ones. The drop in earnings from the third to the fourth quarter amounted to 16% for the 15 larger firms, and only 5% for the 13 medium-size companies. However, in sales, the 15 larger com-

panies showed essentially no change between the third and fourth quarters, whereas sales at the 13 smaller firms dropped 4%. Thus, profit margins for the top 15 chemical companies dropped to 4.0% in the fourth quarter from 4.4% in the third; profit margins for the other 13 fell to 5.7% from 6.4%.

For the full year, earnings for the 28 companies increased 33% from 1983 to \$3.73 billion on a sales increase of 7% to \$70.3 billion. The 15 larger companies had an average earnings increase of 35% to \$3.26 billion and a 6% sales increase to \$61.6 billion. Earnings for the smaller companies grew less at 24% to \$475 million; sales increased 9% to \$8.63 billion.

As a result, profit margins for the larger firms rose faster than did those for the medium-sized companies. Profit margins for the 15 larger firms increased to an average of 5.3% in 1984 from 4.2% during the year before. Those for the smaller companies climbed to 5.5% from an average of 4.8% in 1983.

Because of the better profit picture for the full 12 months, company officials appear more eager to boast about the year than about the fourth quarter, especially since many firms set earnings records in 1984.

At Reichhold Chemicals, chairman and chief executive officer C. Robert Powell says, "We are pleased with the company's performance in 1984. We strengthened our balance sheet, improved our profitability, and continued to make progress toward our goal of 20% return on stockholders equity by the end of 1987."

Vincent L. Gregory Jr., chairman of Rohm & Haas, remarks, "We are very pleased and proud to report our outstanding financial results for 1984. The 1984 performance, coupled with the strong earnings gain in 1983, enabled us to double our earnings in two years. In addition, our return on equity of 18.4% is the highest for the company in over 25 years."

One group that chemicals both helped and hurt in the fourth quarter was the oil companies. In large part, oil company profits were down in the quarter because of softness in the world oil market. In some

Energy company earnings generally fell in fourth quarter, but those for diversified firms rose

	% chemical Sales	FOURTH-QUARTER 1984								FULL-YEAR 1984							
		Sales		Earnings ^a		Change from 1983		Profit margin ^b		Sales		Earnings ^a		Change from 1983		Profit margin ^b	
		(\$ millions)				Sales	Earnings	1984	1983	(\$ millions)				Sales	Earnings	1984	1983
OIL AND GAS COMPANIES																	
American Petrofina	15%	\$ 531.3	\$ 17.3	5%	-26%	3.2%	4.6%	\$ 2,145.2	\$ 45.1	3%	-18%	2.1%	2.6%				
Atlantic Richfield	10	6,004.0	285.0	-7	-32	4.7	6.5	24,654.0	832.0	-1	-46	3.4	6.2				
Chevron	4	7,000.0	275.0	-5	-21	3.9	4.7	29,200.0	1,379.0	0	-11	4.7	5.3				
Diamond Shamrock	23	1,080.2	56.8	-8	def	5.3	def	4,483.2	242.2	11	def	5.4	def				
Exxon	7	24,545.0	1249.0	-1	27	5.1	4.0	94,734.0	4,365.0	-3	-11	4.6	5.1				
Mobil	4	15,600.0	286.0	-3	-36	1.8	2.8	60,600.0	1,037.0	3	-31	1.7	2.5				
Phillips Petroleum	16	4,010.0	193.0	-2	-5	4.8	5.0	15,760.0	791.0	2	24	5.0	4.1				
Shell Oil	14	5,272.0	581.0	1	6	11.0	10.5	20,898.0	1,772.0	5	9	8.5	8.2				
Standard Oil (Ohio)	5	3,207.0	340.0	1	-22	10.6	13.7	12,251.0	1,488.0	2	-2	12.1	12.6				
Sun Co.	3	3,810.0	136.0	-10	-6	3.6	3.4	15,400.0	536.0	-1	3	3.5	3.4				
Tenneco	7	3,844.0	130.0	0	-46	3.4	6.3	14,890.0	631.0	3	-12	4.2	5.0				
Texaco	4	19,002.0	213.0	69	-17	1.1	2.3	48,100.0	1,071.0	17	-13	2.2	3.0				
Unocal (Union Oil)	11	2,970.0	153.4	11	-14	5.2	6.6	11,540.0	700.4	8	12	6.1	5.9				
DIVERSIFIED MANUFACTURERS																	
Allied	22	2,608.0	98.0	6	-17	3.8	4.8	10,734.0	467.0	8	9	4.5	4.5				
Aluminum Co. of America	11	1,386.0	-14.7	-6	def	def	6.6	5,750.8	256.0	-9	56	4.5	3.1				
Beatrice Foods	5	3,748.0	127.0	53	-7	3.4	5.6	11,427.0	433.0	22	14	3.8	4.1				
Borden	18	1,145.3	52.6	-2	0	4.6	4.5	4,568.0	191.4	7	1	4.2	4.4				
Borg-Warner	24	984.1	56.6	3	-1	5.8	8.0	3,915.6	206.1	11	13	5.3	5.2				
Du Pont	32	8,837.0	306.0	-3	-10	3.5	3.8	35,915.0	1,431.0	2	27	4.0	3.2				
Eastman Kodak	23	2,754.0	204.0	7	74	7.4	4.5	10,600.0	923.0	4	63	8.7	5.6				
Englehard	13	642.3	20.2	36	0	3.1	4.3	2,511.0	74.6	20	1	3.0	3.5				
FMC	37	868.8	49.4	-3	-19	5.7	6.8	3,337.8	225.9	3	20	6.8	5.8				
General Electric	17	7,980.0	352.0	7	13	6.2	7.8	27,950.2	2,280.0	4	13	6.2	7.6				
Georgia-Pacific	11	1,766.0	63.0	15	142	3.6	1.7	6,632.0	253.0	11	237	3.8	1.2				
Kaiser Aluminum	19	878.2	-27.8	22	def	def	7.1	3,192.2	7.9	29	def	0.2	def				
Koppers	34	479.8	10.8	8	26	2.2	1.9	1,816.6	47.9	17	146	2.6	1.3				
Ell Lilly	24	777.9	117.8	3	2	15.1	15.3	3,109.2	490.2	2	7	15.8	15.1				
3M	15	1,879.0	174.0	7	7	3.3	9.3	7,705.0	740.0	9	66	9.6	6.3				
Martin Marietta	6	1,116.2	33.3	22	4	3.0	3.5	3,920.4	176.0	21	9	4.5	5.0				
Merck	19	961.9	115.6	12	10	12.0	12.3	3,559.7	493.0	10	9	13.6	13.9				
NL Industries	33	354.4	6.7	7	392	1.9	0.4	1,360.1	18.1	0	def	1.3	def				
Northwest Industries	24	486.4	22.4	10	387	4.6	1.9	1,882.1	77.5	17	962	4.1	0.5				
Pfizer	11	966.3	129.3	-1	6	13.4	12.3	3,854.5	507.9	3	14	13.2	11.9				
Tyler	32	221.1	6.7	4	56	3.0	2.0	928.5	29.0	23	73	3.1	2.2				
U.S. Steel	6	4,659.0	-44.0	-1	def	def	def	19,104.0	106.0	9	def	0.6	def				
Vulcan Materials	29	254.5	13.2	10	-27	5.2	7.8	982.9	74.2	20	37	7.5	6.6				

^a From continuing operations excluding nonrecurring and extraordinary items. ^b Earnings as a percentage of sales. def = deficit.

cases, however, their petrochemical operations improved over the generally dismal showings of the past couple of years. At Standard Oil (Ohio), for instance, chemical earnings increased to \$10 million in the fourth quarter of 1984 from just \$3 million in the same period the year before. For the year, the company's chemical earnings totaled \$44 mil-

lion, up from a \$34 million loss in 1983. A statement from the company says, "Chemical results for the quarter and year reflect higher earnings in both industrial and agricultural chemicals businesses."

At Atlantic Richfield, chemical earnings increased to \$9 million in the fourth quarter from \$6 million in fourth-quarter 1983. For the full

year, the company's chemical earnings totaled \$148 million, up from just \$39 million in 1983.

Shell Oil, Mobil, and Exxon, however, reported much better chemical results for the full year than they did for the fourth quarter. At Shell, fourth-quarter earnings from chemicals fell to \$16 million from \$24 million in the same period the

year before, although its earnings from chemicals for the year more than doubled to \$132 million in 1984 from the previous year.

Mobil recorded a \$19 million loss in its chemical operations in the fourth quarter, compared with a profit of \$14 million in fourth-quarter 1983. For the full year, the company's chemical earnings were \$37 million, up from \$24 million in 1983. At Exxon, the largest chemical producer among the oil companies, chemical earnings for the quarter decreased to \$86 million from \$120 million. For the year, however, they were up, totaling \$423 million, compared with \$270 million the year before.

Only a few markets seemed to show improvement in the fourth quarter and even in these areas results were mixed. One of these was fertilizer. James R. Moffett, chairman and chief executive officer of Freeport-McMoRan, says, "The year ended with strong demand for our agricultural minerals products, and fourth-quarter results from that segment of our business were up 75% over the fourth quarter in 1983."

First Mississippi states that fertilizer pretax operating profits for the first half of its fiscal year (corresponding to the second half of the calendar year) were \$7.2 million, up 108% from the same period the year before on increased prices and margins. International Minerals & Chemical also points to good fertilizer results in the quarter, but W. R. Grace notes weakness in its fertilizer operations.

A related area that did not seem to do well in the fourth quarter was pesticides. At Monsanto, where earnings from agricultural and nutritional products fell to \$37 million from \$77 million in the same period of 1983, president and chief executive officer Richard J. Mahoney says, "Roundup herbicide sales were hurt by adverse weather conditions in Europe in late summer and early fall."

Stauffer Chemical notes that the major factor contributing to decreases in its sales and earnings was a drop in both domestic and international agricultural pesticide sales.

As for 1985, industry executives hope to see better economic times,

but there are concerns. Although many see a slowdown this year, PPG Industries chairman Vincent A. Sarni expects some pickup in the first six months. "In the first half of 1985," he says, "PPG expects to benefit from a faster rate of growth in North America and Europe than occurred in the latter half of 1984. For the year as a whole, some slowing in growth rate is projected for the North American economy. We do not anticipate a similar slowing in Europe."

Monsanto's Mahoney says, "Looking ahead, worldwide industrial and

agricultural product markets look reasonably favorable, although the strength of the U.S. dollar and the possible effects of federal deficits on financial markets continue to be important areas of leverage."

Gregory at Rohm & Haas adds, "Our plans for 1985 assume a reduced rate of economic expansion and continued low inflation in the U.S. economy. Raw materials costs should be flat or slightly down. Our overall performance will depend on the economy for volume growth and our ability to pass on inflationary costs through price increases." □

INTERNATIONAL BUSINESS

U.K. chemicals had strong performance in 1984

Last year was a good one for the British chemical industry, and, although 1985 is not expected to be so good, it still will bring growth to the industry. That is the encouraging message from the new president of the Chemical Industries Association in London, John K. Pitts, chairman and chief executive of Tioxide Group.

Preliminary statistics indicate that in 1984, British chemical production increased 7% over 1983, and is now a few percentage points ahead of the industry's previous record in 1979. Exports grew 12% and domestic sales 4%. Imports, on the other hand, increased 16% and now make up 39% of British chemical consumption. However, with the strong export performance, the chemical industry contributed \$2.18 billion (at \$1.15 to 1 pound sterling) to the British trade balance, Pitts notes with some pride. The manufacturing industry as a whole had a trade deficit of \$1.61 billion.

According to Pitts, improvements in 1984 were fairly widespread but were especially strong in the petrochemical and polymers sector of the industry. How long that will continue, however, is open to question. That sector will face particular problems over the next two years as the products from the Middle East become a major part of the market. Middle East chemicals pressure, in turn, will continue to convince man-

ufacturers to restructure away from commodities and toward specialty chemicals.

End-of-year employment in the chemical industry stood at 332,000 in Britain, and is expected to decline another 2000 this year. "Increases in earnings have largely been contained by improvements in productivity," says Pitts, "but wage costs per unit of output are now rising."

Confirming that prediction is the latest quarterly survey on chemical industry pay settlements in Britain, by Manpower Ltd., a temporary services company. Manpower's survey, by telephone, of leading employers in the industry indicates that the average rate of pay increase in chemical manufacturing this year will be 4 to 6%. Some 35% of chemical manufacturing employers expect the rate to be higher this year than in 1984, although the majority, 55%, expect no change in the rate of increase.

In addition, Manpower's results indicate—despite the Chemical Industries Association prediction of an overall employment decline—that 24% of chemical manufacturing employers are planning staff increases in the first quarter of this year, compared with only 21% of similar employers for the same time last year. Staff losses are projected by 6% of employers in the industry, down from the 10% who planned cuts at the start of 1984. □

NOTE

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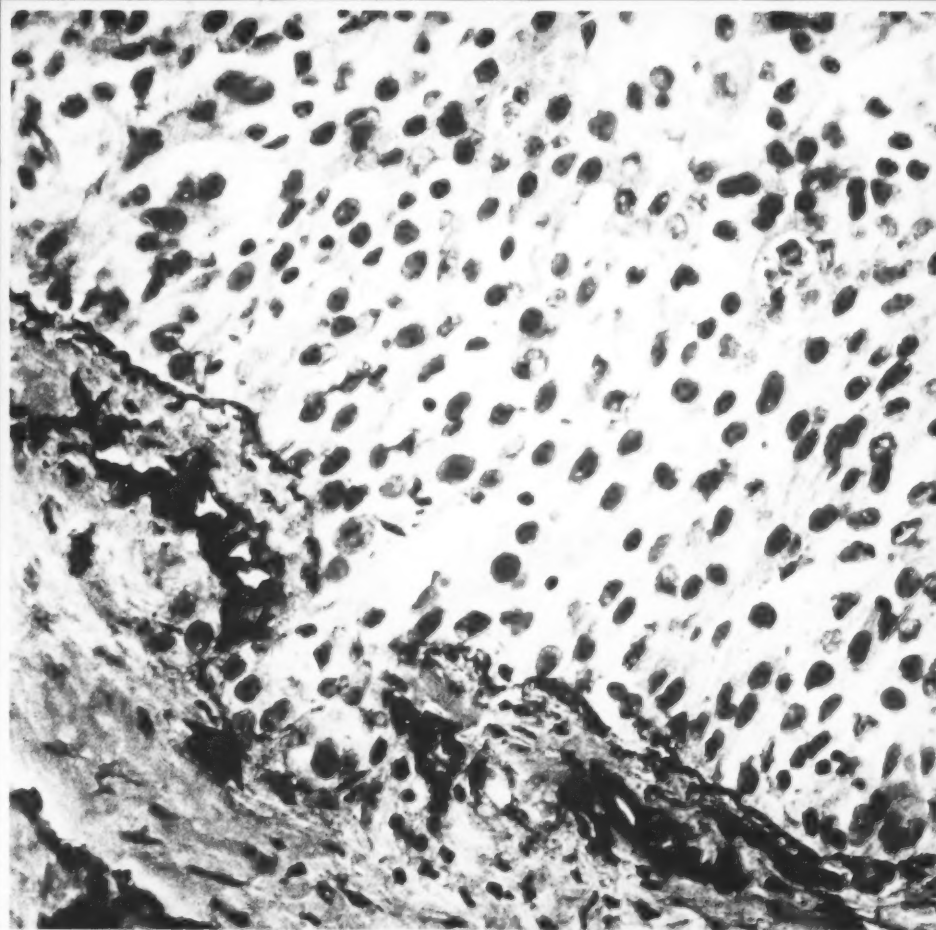
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CHEMICAL & ENGINEERING

NEWS



METASTASIS

Biochemical clues to cancer's invasion process

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News of the Week

■ **Chesebrough-Pond's acquires Stauffer Chemical.** Page 6

■ **EPA sets final regulations on reporting levels of accidental leaks for 340 chemicals.** Page 7

■ **Polymer fiber with high tensile strength ready for marketing.** Page 7

■ **National Institute for Chemical Studies will be set up in West Virginia's Kanawha Valley.** Page 7

■ **President Reagan re-emphasizes role of technological innovation in economic growth at National Medal of Technology awards.** Page 8

■ **OSHA concludes that the chance of an uncontrolled reaction of methyl isocyanate in U.S. is remote.** Page 8

Business

Although growth rates for fertilizer raw materials will decline over the next decade, some shortages are likely. Page 21

Whether suits against Union Carbide stemming from Bhopal will be tried in India or in U.S. is firm's next major hurdle. Page 23

International Business

Second-half 1984 results for Canadian chemical industry were not nearly so good as those of the first six months. Page 24

Government

After three turndowns in as many years, Pentagon is trying harder than ever to get funding for binary chemical weapons. Page 26

Proposed budgets for federal regulatory agencies are mixed: EPA gets an 11% increase but OSHA takes a 3% cut. Page 28

Cost of R&D for development of modern weapons systems has been building up and will escalate further in 1985. Page 29

Science

Direct substitution on cubane nucleus achieved by trapping anions with lithiating reagent mixed with metallic salts. Page 31

Acoustic emission test for integrity of fiber-reinforced plastics, research on pesticide metabolism rewarded by Monsanto. Page 32

ACS News

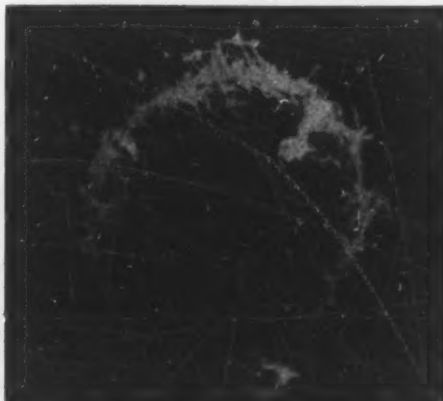
New advisory board members have been selected for the society's journals; most will serve three-year terms. Page 34

Cover: Metastatic cells (lower left, indicated by arrow) break off from human breast cancer tumor. Photo courtesy of Lance A. Liotta, National Cancer Institute

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News Focus

Biochemistry of metastasis must be known to block cancer cell invasion, an important step in possible control of cancer. Page 10



Global Outlook for Fertilizer Raw Materials: Cautious but Positive

Even though growth rates will decline, shortages loom for raw materials unless producers begin preparing soon for capacity additions

Patricia L. Layman, C&EN London

It was an international gathering, set to assess the international outlook for raw materials for the fertilizer industry over the next decade or so. Speakers at the conference, sponsored by British Sulphur Corp. and held in London earlier this month, picked out potential trouble spots for the industry's coming years. But they also reached the conclusion that, overall, the world outlook for fertilizer raw materials is cautious but positive.

That, in particular, was the message from Gino P. Giusti, president of Texasgulf Inc., of Stamford, Conn., who opened the conference

with a broad overview of fertilizer raw materials to the year 2000. Giusti briefly traced the growth patterns of the industry over the past 20 years—total fertilizer consumption growth of an average 5.7% per year, with growth in all three of the basic nitrogen, phosphorus, and potassium (NPK) nutrients. Growth has been especially strong in areas other than the developed noncommunist countries (North America, Western Europe, Oceania, Israel, Japan, and South Africa), which accounted for about two thirds of the total fertilizer market in 1965 but now only about 39%. Communist countries—Eastern Europe, U.S.S.R., China, and other communist countries in Asia—account for 41% of the total now, up from 25% 20 years ago. And developing nations—Latin America, Africa (excluding South Africa), and noncommunist Asian countries (excluding Japan)—account for 20%, up from 9% in 1965.

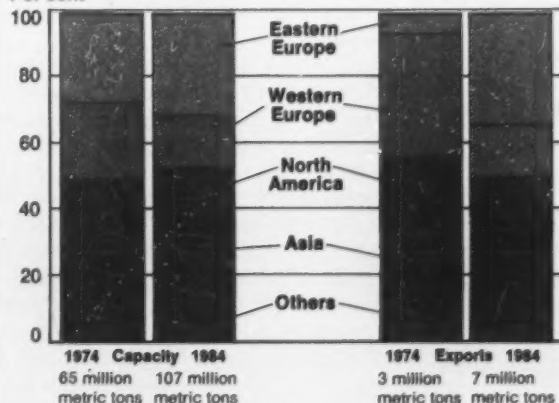
Giusti expects NPK fertilizer consumption to reach about 211 mil-

lion metric tons in the year 2000, up nearly 70% from the anticipated level of 125 million metric tons this fertilizer year. During the next 15 years, nitrogen fertilizer use likely will grow 13.5% per year, phosphorus 3.1% per year, and potassium 3.5%. These rates, if achieved, would be an improvement for nitrogen-containing fertilizers, up from an annual rate of 7.4% over the past 20 years, but a decline for phosphorus and potassium fertilizers, each down from an annual growth of 4.3% over that time.

Consumption of fertilizers in the developed noncommunist countries is expected to grow at only 2.3% per year over the rest of the century, and that in communist countries, 2.9% per year. On the other hand, consumption of fertilizers in the developing countries will increase at nearly 6% per year to the year 2000, Giusti predicts, despite the strain placed on these countries by spending scarce money on fertilizers rather than on other necessities.

North American share of ammonia capacity, exports has shrunk

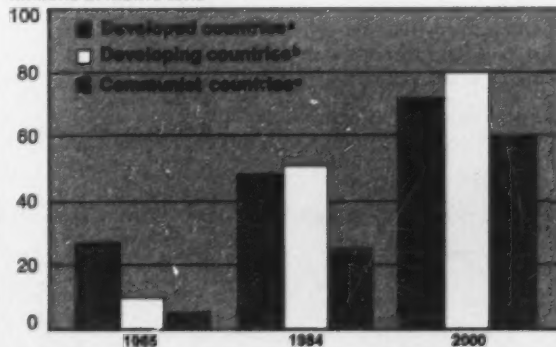
Per cent



Source: Unie Van Kunstststofffabrieken B.V.

Developing countries to remain biggest fertilizer user

Millions of metric tons



^a North America, Western Europe, Oceania (Australia, New Zealand, Micronesia, Melanesia, Polynesia), Israel, Japan, and South Africa. ^b Latin America, Africa (excluding South Africa), and noncommunist Asia (excluding Japan). ^c Eastern Europe, U.S.S.R., and communist Asia. Source: Texasgulf

Even with declining growth rates, however, shortages loom for fertilizer raw materials, unless the industry begins preparing soon for capacity additions. The next major round of additions needs to occur in the early 1990s, Giusti says.

For example, effective nitrogen capacity, figured at 85% of nameplate capacity, probably will fall short of projected production requirements by about 1993. Even worse, the effective capacities for phosphate rock and potash will fail to meet production needs by about 1989, he forecasts. And the capacities themselves likely will begin to fall after 1990, when the U.S. industries begin to deplete their mines—after the Florida phosphate rock industry begins rapidly depleting its existing mines, and as potash mines are depleted.

Similarly, sulfur, a crucial ingredient for processing phosphate, will see constraints on availability. U.S. Frasch sulfur reserves are diminishing, Canadian stockpiles are being worked down, and existing sour-gas reserves are being depleted.

According to Giusti, Texasgulf estimates of capital requirements indicate that about 200 new world-scale fertilizer plants will be required by the year 2000. The cost of building the plants, in constant 1984 dollars, is estimated at about \$66 billion. Moreover, refurbishing existing plants will require an additional \$42 billion, making a total

capital requirement of about \$108 billion. Because of that staggering sum, Giusti adds, "I believe that future investment in new or expanded fertilizer production capacity will be more cautious."

Where the investments are made also will follow shifting trends, other speakers at the conference indicated. A case in point is sulfur. The sulfur industry already has survived one major revolution, as it changed from an industry once dominated by Frasch sulfur in the 1960s to one ever increasingly reliant on sulfur recovered from hydrocarbons. And the U.S. and Canada historically have been the primary producers and exporters of sulfur.

But as Jared E. Hazleton, of the Texas Research League in Austin pointed out, the U.S. Frasch sulfur industry has a bleak future. Identified and other reserves of Frasch minable sulfur were only 101 million metric tons, according to estimates at the end of 1983, significantly lower than adjusted 1970 estimates of 184 million metric tons. And production from Louisiana and Texas was 3.2 million metric tons in 1983, the lowest level of production since 1943. Production increased somewhat in 1984, Hazleton believes, probably topping 4 million metric tons. Nonetheless, the trend for U.S. Frasch sulfur is downward.

Similarly, Canadian sulfur production (in Alberta) has been "in a state of decline since 1973," according to

David K. Arnott of Cansulex Ltd., industry consultants in Vancouver, B.C. Thanks to a massive stockpiling before 1979, Canada has seen sales of sulfur increase from 4.1 million metric tons in 1973 to nearly 8 million metric tons last year. However, the current inventory level is about 12 million metric tons, says Arnott, and the rate of removal last year was almost 3 million metric tons. As the rate of stockpile depletion accelerates, he predicts, the expected lifetime of the inventory is being reduced to the point where total depletion is expected by the end of the decade. Reserves are still large, both in present hydrocarbon production and also in the potential form of recovery from ultrahigh sour gas currently under R&D.

However, Canada will cease to be the dominant world producer of recovered sulfur by 1990, predicts Robert Boyd of British Sulphur Corp. in London. Western European countries as a group will be the single largest producing block, closely followed by the Soviet Union toward the end of the 1990s, as the Soviets recover sulfur from their Caspian Sea hydrocarbons. And by the end of the century, the Middle East also will be an important producing region, recovering sulfur from the natural gas that once was flared.

Poland will be the dominant producer of Frasch sulfur by 1987, Boyd adds. It has been producing at a relatively steady 5 million metric tons per year since the late 1970s, he says, and will continue to produce at that rate to obtain foreign currency through exports.

Eastern European countries have become the major exporter, too, of ammonia.

The U.S. is the third largest producer of nitrogen products, following the U.S.S.R. as leading producer (China is the second largest). And Middle Eastern producers are increasingly important world-trade suppliers, points out P. J. T. Samuels of Unie Van Kunststestfabrieken of Utrecht, the Netherlands. The Soviet Union, the U.S., and the Arab countries all rely on natural gas as the raw material for ammonia production. Samuels predicts that will remain the favored starting material. □

Shortage of fertilizer may develop by 2000

Millions of metric tons	Nitrogen	Phosphate rock	Phosphate (P ₂ O ₅)	Potash (K ₂ O)	Total
World annual demand	135.1	245.1	63.0	47.0	490.2
Current annual capacity	115.7	189.2	47.6	35.3	387.8
Additional capacity required ^a	43.2	99.2	26.5	20.0	188.9
Number of new plants required	75	25	76	23	199

^a Based on 85% operating rate. Source: Texasgulf

World potash consumption may grow 40% in next 10 years

Millions of metric tons of K ₂ O	1983-84	1988-89	1993-94
Developed countries ^a	12.17 (49%)	13.81 (46%)	15.08 (44%)
Developing countries	3.27 (14%)	4.48 (15%)	5.64 (16%)
Communist countries	9.25 (37%)	11.55 (39%)	13.85 (40%)
TOTAL	24.69 (100%)	29.84 (100%)	34.57 (100%)

^a Noncommunist. Source: Kali & Salz A.G.

Second Half Deflates Canadian Chemicals

1984 wasn't a particularly bad year for the Canadian chemical industry. But it wasn't a particularly good one, either. And it certainly would have been a lot better if it had ended at the midway mark.

During the first six months of the year, sales were up substantially for most Canadian chemical companies. Earnings bounced back dramatically from the pits, where they'd been during all of 1982 and early 1983.

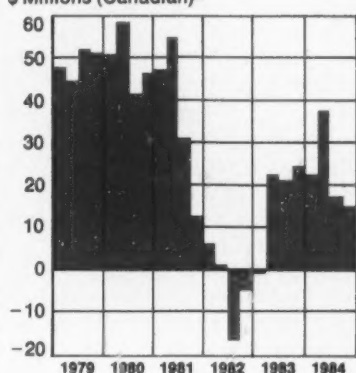
However, much of the gains that the Canadian chemical industry scored in the first half of 1984 were wiped out in the second half. The combined results of the four large, publicly reporting firms tracked by C&EN (C-I-L Inc., Celanese Canada, Du Pont Canada, and Union Carbide Canada) tell the story clearly.

During the first half of the year, the combined sales of these four companies increased 9% over first-half 1983. But in the second half, sales were 9% lower than they were in the first six months. The result: a modest and no doubt disappointing 3.9% increase in sales for the full year.

The second-half impact on their combined earnings was much more severe. Here's how those earnings progressed by quarter: The first quarter brought a \$22.5 million (Canadian dollars throughout) profit compared with a \$1.0 million loss in first-quarter 1983. In the second quarter, earnings were up 67%. But in the third and fourth quarters, earnings were down 16% and 39% from the corresponding 1983 quar-

Combined earnings taper off in second half

\$ Millions (Canadian)*



* After-tax earnings of four largest publicly reporting Canadian chemical companies—C-I-L, Celanese Canada, Du Pont Canada, and Union Carbide Canada.

ters, respectively. As a result, earnings that were 183% higher than in 1983 at the halfway mark were only 38% better by the end of the year. Good, but also disappointing.

Most major Canadian chemical companies followed the good-first-half, poor-second-half pattern. Some had unfortunate losses from extraordinary expenses that ate into otherwise respectable 1984 earnings. And some fared much better than others.

Perhaps because it is a more diversified company, C-I-L increased its 1984 earnings over 1983 much more than its three other Big Four counterparts. Although C-I-L's sales were

up only 5.6% to \$1.18 billion last year, earnings, excluding extraordinary items, jumped a hefty 59% to \$38 million.

But C-I-L's \$38 million net income from operations has to be tempered by a \$3 million extraordinary loss. This resulted from a \$4.5 million loss attributable to plant closings coupled with a \$1.5 million gain from the sale of Hanson, its electroplating chemical subsidiary.

The particular problems of other companies were more severe. For Celanese Canada, the problem was textiles. Union Carbide Canada's concern was petrochemicals.

Celanese enjoyed strong sales in its chemicals and industrial products group, even during the fourth quarter. But these were more than offset by lower sales volumes and margins in the textile group. Textiles probably will face tough sledding throughout the first half of 1985, Celanese says. The company wants the Canadian government to reduce the flow of imported garments into Canada from countries with low labor costs.

Improved performance in industrial gases and carbon products helped Union Carbide Canada to rack up earnings of \$5.7 million last year, compared with a net loss of \$1.4 million in 1983. But write-downs associated with the company's petrochemical operations resulted in a net loss of \$28.2 million.

Carbide Canada's extraordinary loss included a nearly \$31 million write-down of its investment in Petrosar, the petrochemical core company in Sarnia, Ont. Another \$4.4 million was written off on its Montreal East polyethylene plant, which figured prominently in the recent troubles of Pétromont, the core petrochemical company in the Montreal area. Carbide Canada owns 50% of Pétromont, and the company's 1984 results reflect about \$12 million in government aid given to Pétromont last year.

Earl Anderson, New York

Sales were up, but earnings were mixed bag

\$ Millions (Canadian)	FULL-YEAR 1984					
	Net sales	Change from 1983	Net income ^a	Change from 1983	Profit margin ^b	1983
C-I-L Inc.	\$1176.0	5.6%	\$38.0	59.0%	3.2%	2.1%
Celanese Canada	387.4	2.3	7.8	-17.0	2.0	2.5
Du Pont Canada	1170.6	4.9	41.2	17.0	3.5	3.2
Union Carbide Canada	691.4	0.6	5.7	c	0.8	c
TOTAL	\$3425.4	3.9%	\$92.7	36.2%	2.0%	2.7%

a Net income from continuous operations, excluding extraordinary gains or losses. b Net income as percentage of sales. c Data for 1983.

proliferation as well as the other issues raised in the posture paper play in Congress this year. No matter what emotions they stir, they may become totally irrelevant if the Presidential chemical warfare review panel decides in favor of a small modernized—the codeword this year for binary—stockpile, a finding considered likely.

Another question mark is Rep. Aspin, now chairman of the House Armed Services Committee. Aspin consistently has voted against binary weapons. But he may decide to

use the issue as a bargaining chip—the way he changed his vote on the MX missile—to prod the Administration to a chemical arms accord.

The Pentagon's request for binaries is expected to be turned down again. However, says one Congressional observer, "With Ed Bethune gone [as a Representative from Arkansas, he was a leading opponent of the binary], with Aspin and the Presidential panel question marks, and with the Administration pulling out all the stops, it's going to be a tough year for binary opponents." □

EPA fares well among '86 regulatory budgets

Among the federal regulatory agencies, only one—the Environmental Protection Agency—fared well in the Administration's budget proposal for fiscal 1986 submitted earlier this month to Congress. Budgets for the other regulatory agencies that interact in one way or another with the chemical industry are either frozen at or cut from fiscal 1985 levels.

Hazardous waste gets top priority in EPA's budget proposal. Funding for the Superfund program, which finances evaluation and cleanup of abandoned hazardous waste sites, would increase 45% from this year's budget to \$900 million. Funding for programs aiming to curb future hazardous waste problems is slated to rise 26% to \$236 million.

In setting its 1986 Superfund budget targets, EPA is assuming that when Congress reauthorizes the law this year the taxes that finance Superfund will be set at a substantially higher level than they are now. And all of the financing will come out of industry's pockets. The Administration will not request a renewal of the annual government payment of \$44 million that has been made to fund the program over the past five years.

Out of the \$900 million budget, \$760 million is earmarked primarily for remedial design and construction actions. Engineering designs for Superfund sites will increase from 64 in 1985 to 89 in 1986. Remedial constructions, the final and most

expensive phase of the cleanup process, are expected to increase 124% to 56 in 1986. EPA also intends to begin planning work at an additional 130 sites, bringing the total of sites where planning has begun to 536 by the end of 1986.

Much of the \$67 million increase slated for hazardous waste activities under the recently amended Resource Conservation & Recovery Act is expected to be used internally by EPA on developing and promulgating the more than 70 major regulations that are now required. These include banning waste from land disposal, identifying alternative treatment technologies and pretreatment standards for those banned wastes, and developing timely and effective regulations for small-quantity generators. In addition, \$70 million will be allocated to the states for underground storage tank activities.

Turning to other regulatory agencies, proposed funding for the Food & Drug Administration is essentially frozen at \$408 million, with a staff reduction of about 200 slated for 1986. Funding for the Justice Department's environmental enforcement activities also is being held constant at just over \$22 million, as is funding for the antitrust division at \$43 million.

The proposed budget for the Occupational Safety & Health Administration is 3% lower than in the current fiscal year, down to \$213 million. Even with decreased funding, the agency says it can still support the same number of inspections in 1986 as it plans this year: 71,400; support the same number of

EPA's budget is up 11% . . .

\$ Millions	1985 ^a	1986 ^a	1984 ^b
Superfund	\$ 900.0	\$ 620.0	\$ 460.0
Management and support	283.6	293.4	251.9
Water quality	238.6	248.2	217.8
Air	236.1	235.8	222.6
Hazardous waste	235.8	186.6	129.4
Toxic substances	93.7	82.9	119.4
Drinking water	87.2	87.0	77.5
Pesticides	69.3	67.7	57.1
Energy	67.2	58.1	36.7
Radiation	9.6	11.9	11.3
TOTAL	\$2220.5	\$1991.6	\$1583.7

. . . FDA's stays even . . .

\$ Millions	1985 ^a	1986 ^a	1984 ^b
Drugs	\$152.4	\$153.1	\$138.2
Foods	113.9	109.5	115.5
Devices, radiological products	68.4	67.1	62.6
Program management	50.6	58.2	50.2
National Center for Toxicological Research	22.3	21.6	21.1
TOTAL	\$407.6	\$409.5	\$387.6

. . . but OSHA's is cut 3%

\$ Millions	1985 ^a	1986 ^a	1984 ^b
Enforcement	\$136.0	\$137.1	\$134.4
Federal	83.0	84.1	84.8
State	53.0	53.0	49.6
Compliance assistance	34.8	37.9	38.9
Safety and health statistics	17.9	21.0	16.2
Technical support	13.7	13.2	12.8
Safety and health standards	6.0	6.2	5.0
Administration	5.0	5.4	6.4
TOTAL	\$213.4	\$220.8	\$214.6

^a Estimate. ^b Actual. Note: Obligations. Source: Office of Management & Budget

state program inspections: 108,000; and visit the same number of workplaces for consultation: 25,600.

The Federal Trade Commission's efforts, as the budget document says, "to eliminate threats to fair and honest competition from all sources" will have to go forward with a 3% reduction in funding to \$64 million. The Consumer Product Safety Commission's efforts to protect the public from hazardous products is scheduled to proceed with 6% less funding at \$33.7 million.

Janice Long, Washington

R&D cost of weapons continues to escalate

The massive commitment of U.S. scientific and technological resources to the development of new weapons systems that has been building up these past four years will continue unabated. That is an unmistakably clear message contained in Secretary of Defense Caspar W. Weinberger's 1985 report to Congress.

The 314-page document was submitted earlier this month in support of the Administration's budget for fiscal 1986. That budget pegs the Department of Defense's research, development, testing, and evaluation program at \$39.3 billion, up 25% from fiscal 1985 and 45% from fiscal 1984. Why the Pentagon insists it needs such massive increases in R&D funding becomes clear from the details given in Weinberger's report of the massive expense of developing modern weapons systems, particularly strategic systems.

For instance, the Trident II is a submarine-launched ballistic missile (SLBM). It is scheduled to be deployed in late 1989. It is of longer range and it carries more powerful nuclear warheads than the Trident I and Poseidon SLBMs that are currently in service. Trident II will be the first SLBM accurate enough to strike effectively at missile silos and other hardened targets.

Initial R&D on the Trident II was under way during the Carter Administration. The weapon is now at the full-scale development stage. Development funding of the Trident II reached \$1.47 billion for fiscal 1984

and for 1985 it was \$2.05 billion. For 1986 it is set at \$2.17 billion and for 1987 at \$1.72 billion.

A ballistic missile that is at an earlier stage of development is the so-called Midgetman. This is a relatively small, land-based weapon. It will weigh less than 30,000 lb and carry a single warhead. It will enter full-scale development during fiscal 1987 and will be deployed, in a mobile launcher system, beginning in the early 1990s. R&D funding for this missile and launcher are set at \$625 million for fiscal 1986. Development funding, starting in fiscal 1987, will be much higher.

A strategic weapons system nearing the end of its development cycle is the MX intercontinental ballistic missile (ICBM). Development started more than a decade ago. Present plans call for the deployment of 100 of these missiles in existing Minuteman III silos beginning in late 1986. Each MX will carry 10 relatively large and very accurate nuclear warheads. As Weinberger explains, the MX "is the only near-term answer for providing a prompt capability to hold time-urgent Soviet assets at risk." This Pentagonese means, among other things, that MX theoretically has the ability to knock out large Soviet ICBMs in their silos. It reciprocates the potential ability of Soviet ICBMs to knock out any silo-based U.S. ICBM, including the MX itself. Development funding for MX was \$1.96 billion in 1984. It is set at \$1.70 billion for 1985. And it is slated to decline to \$805 million for 1986.

Another strategic weapons system that, like MX, is moving from development to deployment is the B-1B bomber. The first of 100 production aircraft is off the assembly line. However, development funds are still being spent on the system—\$465 million in fiscal 1985 and a proposed \$367 million for fiscal 1986. Funding for development of a more advanced bomber scheduled for deployment in the mid-1990s is building up rapidly. But the amount is being withheld as classified information.

Another strategic program very much on the upswing in terms of R&D funding is the effort to explore the feasibility of protecting the territory of the U.S. and its allies from ballistic nuclear missiles. This program will be strictly limited to the research and very early development stages for some years. Anything more would violate the antiballistic missile treaty to which the U.S. is a party. Even so, very major monies are involved. Spending for what is now called the Strategic Defense Initiative for fiscal 1985 is \$1.40 billion. For 1986 it will be \$3.72 billion and for fiscal 1987, \$4.91 billion.

The ultimate goal of such a shift to defensive systems is to move away from the present doctrine of deterring nuclear war by maintaining the ability to retaliate and obliterate any enemy who attacks (mutual assured destruction—MAD). The idea is to move to a doctrine of mutual assured defense. This would eventually render ballistic missiles impotent and lead to their elimination. Critics are not very impressed with the whole concept. They argue it never will be possible to defend population centers because missiles can readily be modified to stay ahead of developing defensive systems. Their greatest fear is that any systems developed under the initiative could end up being deployed only for the defense of missile silos. This would, in effect, exacerbate the uncertainties of MAD by pushing it to higher and more dangerous levels of technical action and counteraction as each side strove to maintain the viability and effectiveness of its retaliatory forces.

Michael Heylin, Washington

R&D funding for major strategic systems on the rise

\$ billions	Fiscal year		
	1984	1985	1986
MX intercontinental ballistic missile	\$1983	\$1700	\$ 804
Small intercontinental ballistic missile (Midgetman)	323	426	825
Trident II submarine-launched ballistic missile	1473	2044	2186
B-1B bomber	737	465	367
Strategic defense initiative (Star Wars)	50	1397	3722
Strategic surveillance, command, and communication	1072	1346	1384
Advanced strategic missile systems	74	98	174
TOTAL	\$5813	\$7419	\$9085

Source: Department of Defense

Chlor-alkali growth
will slow in 1985
A Key Chemicals Review Page 11

MARCH 4, 1985

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News of the Week

■ Administration's Superfund bill proposes five-year extension of the law with money collected solely from taxes. **Page 6**

■ Union Carbide gets good news from its auditors, criticism from the French and Indians. **Page 7**

■ Six chemists receive the National Medal of Science. **Page 7**

■ Senate bill would ban import of benzidine and benzidine-based products. **Page 8**

■ Joint project to provide continuously updated alloy phase diagrams reaches financial goal of \$4 million in private funds. **Page 8**

■ Plan for distributing money to claimants in agent orange settlement filed. **Page 8**

Cover: Chrysotile asbestos in natural state.
Photo courtesy of Bureau of Mines

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Business

After strong gains in 1984, chlor-alkalies will resume the slow growth traditional with these products. **Page 11**

Pharmaceutical firms' fourth-quarter earnings were modest; strong U.S. dollar plus increased R&D outlays slowed growth. **Page 16**

Government

U.S.'s ability to compete in global markets is slipping, foreign goods getting better and cheaper, commission reports. **Page 21**

Science

Chromosome-specific human gene libraries made available by two national labs for use primarily by medical geneticists. **Page 24**

Technology

Hollow-fiber membrane units for on-site nitrogen, developed by Dow and Monsanto, compete for variety of applications. **Page 26**

A fault-tolerant programable process controller that is also triply redundant is initial offering of California firm. **Page 26**

ACS News

Robert W. Cairns, former president, board chairman, and executive director of ACS, is dead at the age of 75. **Page 42**

Three new society publications concern hazardous waste, health risks from chemical exposure, lab waste chemicals. **Page 43**



Special Report

Asbestos, once acclaimed for its fire-extinguishing properties, now is under fire for its hazards to health. **Page 28**

Chlor-Alkalies Return to Slow Growth Pattern

Lower growth rates in demand for chlorine, caustic soda, and soda ash end capacity expansion and will keep pressure on prices

Bruce F. Greek, C&EN Houston

A return to normal is in store for the chlor-alkali industry. After wallowing in the recession and then posting strong gains last year, chlor-alkali producers will return to the familiar pattern of historical slow growth. Also, they will continue to see overcapacity brought on largely by a building spurt in the mid-1970s. Foreign competition will only add to their problems.

Thus, no major changes are expected in this industry's major volume products—chlorine, caustic soda, and soda ash—for quite some time. Demand and production growth are falling toward the lower rates traditional for these products. No ca-

capacity expansions in the U.S. are expected before late in this decade, if then, since current and projected plant operating rates will grow so slowly that it will be a long time before capacity already in place returns to the high use rates that once characterized this industry.

This year will set a pattern for the rest of the 1980s. No additions to capacity and slow demand growth mean that price action will be mi-

Key Chemicals

nor, other than increases reflecting any rise in basic energy costs. However, this does not mean that pressure on prices will abate. Exports of caustic and soda ash and of chlorine as various derivatives will fall or, at best, hold even in this decade.

Growth of chlor-alkali markets will be influenced strongly by growth in the U.S. economy. However, chlor-alkali growth will be less than expansion of the gross national

product because of a drop in exports of chlorine derivatives and caustic soda forecast to begin either this year or soon after.

Projections for long-term demand growth for chlor-alkalies range from 1 to 2% per year. Wrinkles caused by economic downturns similar to those in the past could upset even this conservative estimate. If net growth over the next five years totals 10% for each of the major-volume chlor-alkalies, in 1990 production of chlorine could reach about 12.1 million tons, of caustic soda about 12.8 million tons, and of soda ash about 9.4 million tons.

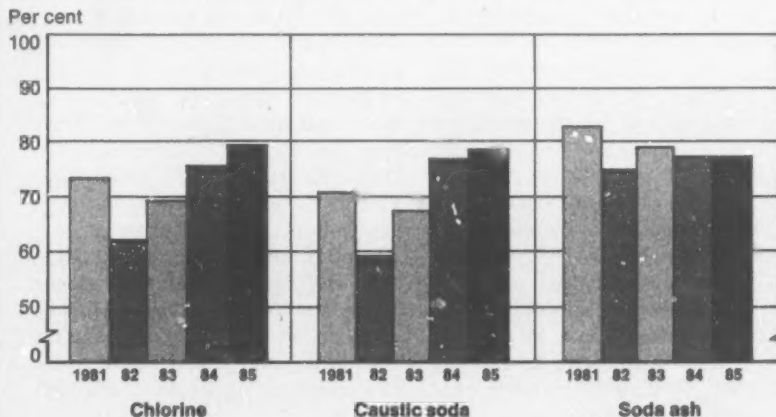
None of these production forecasts will exceed the current in-place nameplate capacities of 14.0 million, 14.6 million, and 11.0 million tons for chlorine, caustic soda, and soda ash, respectively.

Capacity in fact may decline over the next several years, primarily because of the usual economic factors. For example, efforts to improve plant efficiencies have been under way for several years as a result of the development of membrane technologies. However, conditions at some plants are such that they override conversion of electrolysis cells to the use of membranes. These plants are likely candidates for shutdown during the next recession.

Foreign competition for markets may reduce U.S. exports, forcing product back into U.S. markets and putting more pressure on prices and capacity. Foreign producers of caustic soda and chlorine derivatives easily could have significantly lower energy costs from such sources as low-cost gas in the Middle East or from hydroelectric and nuclear power in Europe.

For details of the near-term outlook for the major volume chlor-alkalies, see the following pages.

Operating rates are up for chlorine and caustic soda



Sources: Industry and C&EN estimates, Chlorine Institute, Bureau of Mines

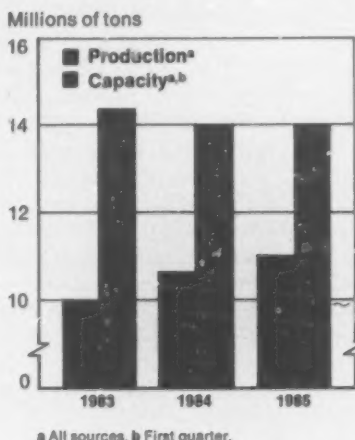
Key Chemicals



Chlorine

- **Production up slightly**
- **Capacity on hold**
- **Prices improved**

PRODUCTION/CAPACITY



MAJOR PRODUCERS

Diamond Shamrock, Dow Chemical, Occidental Chemical, Olin, PPG Industries, Vulcan Materials

HOW MADE

Electrolysis of NaCl brine; recovery from hydrochloric acid; coproduct of metals manufacture

MAJOR DERIVATIVES (U.S.)

Ethylene dichloride 20%, other C₂ derivatives 10%

MAJOR END USES (U.S.)

Organic chemicals and plastics 65%, pulp and paper manufacturing 15%

FOREIGN TRADE

Exports—declining to about 25,000 tons, imports—rising to about 250,000 tons in 1985

PRICES

List prices \$195 per ton

The recovery for chlorine will continue through this year. The general business recovery is pushing growth in chlorine demand into 1985 along with a price increase that is holding up reasonably well.

During 1985, chlorine production likely will post a gain of 3 to 4% to bring the total for the year to about 11 million tons. This production growth will be smaller than that in 1984, when output was up more than 4%. After slowing toward the end of 1984, production now appears to have improved in anticipation of an increase in demand that usually develops in the first half of the year. This increase in chlorine demand results mainly from demand for polyvinyl chloride pipe and other fabricated products used in construction.

Chlorine capacity—about 14 million lb—will be even with 1984 capacity through most of this year. Minor shifts in capacity may occur as projects to improve efficiency, such as changing to new membranes in electrolysis cells, continue, or as small plants at paper mills are shut down after an analysis of the economics favors a "buy" decision over the current "make" situation. But no major new chlor-alkali plants are expected to be built in the U.S. for several years, possibly not until the 1990s.

As a result of the small gain in chlorine production that is forecast for 1985 and the hold on capacity, the average operating rate will be about 78 or 79%. The percentage rate likely will fluctuate between the low 70s and the low 80s, with the second quarter of 1985 having the best operating rates of the year. Toward the end of 1985, if a significant business slowdown occurs for chemicals, the operating rate will drop down into the high 60s again, as it did in December 1984.

The improvement in economics for chlorine producers seen in 1984 will continue, at least during the first half of 1985, as a result of better plant operating rates. Price increases, bring-

ing the list price to \$195 a ton at Gulf Coast plants and higher at other plants and terminals, have helped. Although actual sales prices continue to be lower than list prices, the list price increases do carry over to better profitability.

Simultaneously, energy costs currently are lower. A surplus of natural gas along the Gulf Coast has put pressure on prices for gas sold to industrial customers, reducing some spot sale prices 5 to 10%. How long this aid to production costs will last sparks strong arguments, but the benefit likely will hold until well into 1986, according to most industry sources.

Most of the demand growth for chlorine stems from PVC. Ethylene dichloride, a precursor to vinyl chloride used to make PVC, holds the position of being the largest, as well as a still-fast-growing, market for chlorine. However, cycles in demand for PVC products, such as pipe, do significantly affect chlorine operating rates. Such a cycle occurred in 1984 when demand for PVC pipe seemed to be rising rapidly in the spring to meet expected housing construction. Inventories of the polymer rose until they were recognized as being too high at the beginning of the summer. Inventory reduction began and soon had spread back down the production chain to chlorine, causing a drop in output during the third quarter of 1984.

Other end uses of chlorine, such as pulp and paper manufacturing and some chemicals manufacturing, have been relatively strong in their demand for chlorine recently and are expected to hold up as long as the economy does well. Exports of chlorine derivatives, including ethylene dichloride, may slow during 1985 and offset some of the gains in U.S. consumption.

Consequently, two reasonably good years back-to-back are in the making for chlorine. During this time, chlorine producers will be able to put some of their capital into better efficiency, but they cannot go so far as to add any capacity.

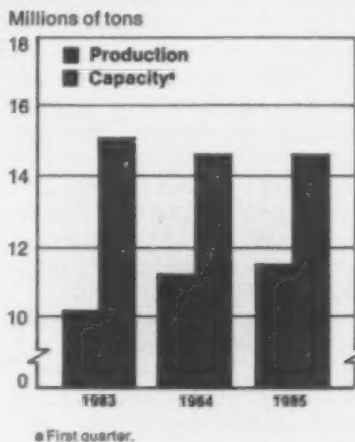
Key Chemicals

NaOH

Caustic soda

- **Production rising**
- **Capacity stable**
- **Prices stronger**

PRODUCTION/CAPACITY



MAJOR PRODUCERS

Diamond Shamrock, Dow Chemical, Occidental Chemical, Olin, PPG Industries, Vulcan Materials

HOW MADE

Electrolysis of NaCl brine

MAJOR DERIVATIVES (U.S.)

None taking more than 5% of consumption

MAJOR END USES (U.S.)

Chemical manufacture 50%; pulp and paper manufacture 20%

FOREIGN TRADE

Exports—declining to about 1.1 million tons, imports—rising to about 500,000 tons in 1985

PRICES

List prices at Gulf Coast plants \$175 per ton; prices higher at other locations

In addition to the obvious coproduct situation, caustic soda production is rising for many of the same economic reasons as chlorine. Strength in the economy increases the demand for chemicals that are made using caustic, either as a source of sodium ions or as a processing aid, such as in neutralization.

Production growth for finished caustic in 1985 will be slightly less than will be reported for chlorine. Caustic output will be up less than 3% to 11.5 million tons, after a 10% rise in production during 1984.

The difference in the growth between chlorine and caustic is caused by the differences in their sources and in their final processing. Although different processes and brines can be used to make chlorine, caustic soda comes almost entirely from electrolysis of sodium chloride brine. Not all of the caustic soda in solution from the electrolysis cells is finished or concentrated to the usual commercially available solutions of 50% or 70% or made into dry caustic. This unfinished caustic is used as a neutralizing agent in other units at the same plant site where it is made.

Capacity to produce caustic is greater than capacity to produce chlorine because of the stoichiometry of the electrolysis. But it is not changing at all, other than as a result of efficiency improvements to the cells. (Chlorine capacity changes slightly more than does caustic capacity because of sources of chlorine other than sodium chloride brine.) Because exports of caustic—now slowing—are a proportionately larger part of demand, less pressure to expand capacity exists than that for chlorine.

Plant operating rates this year will be nearly the same as 1984: about 78% of nameplate. This includes some small amount of capacity shutdown. At this level, it seems unlikely that any shutdown capacity will be restarted anytime soon or that any new capacity will be built.

The export markets for caustic, accounting for about 10% of production, are a special cause for concern to chlor-alkali producers. The export business rebounded in 1983 and continued strong in 1984, reaching 1.3 million tons. This was close to the record set in 1979. But currently sliding exports will continue to slide as chlor-alkali industries develop in countries with much-lower-cost energy.

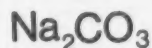
Imports of caustic into the U.S. are rising from countries other than the traditional ones, such as Canada. These imports come from countries that have lower energy costs, either direct or subsidized, and that are attracted by the strong dollar. The greater imports plus lower exports reduce the favorable trade balance.

This trade-balance effect tends to put pressure on caustic prices, which were raised in 1984. So far, prices, though discounted significantly from list prices, have held up. Prices could go higher, according to some industry sources, because caustic may have to carry a larger share of the production cost of an electrochemical unit, which is 1 ton of chlorine and about 1.1 tons of caustic. Caustic's share of an electrochemical unit will rise because of possible softer chlorine demand if shipments of PVC ease during the second half of 1985.

Demand strength for caustic comes mainly from the big catch-all use category—chemicals manufacture. Often, caustic used in chemicals simply passes through the process and is regenerated. But some caustic is lost in most processes requiring constant addition. A similar situation exists for pulp and paper manufacturing.

Demand for caustic in 1985 will remain strong enough to keep production rising another year, even in the face of a less favorable trade balance. With net exports possibly slowing and U.S. demand growing slowly, chlor-alkali producers will have the same struggle with profitability that they have had.

Key Chemicals

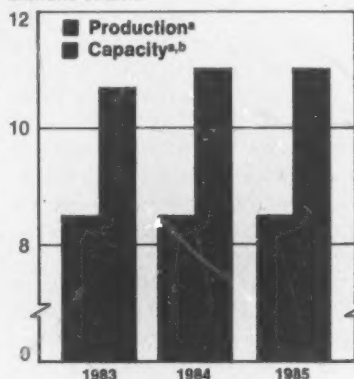


Soda Ash

- **Production holding**
- **Capacity level**
- **Prices not moving**

PRODUCTION/CAPACITY

Millions of tons



^a Natural and synthetic. ^b First quarter.

MAJOR PRODUCERS

Allied, FMC, Kerr-McGee, Stauffer Chemical, Tenneco, Texasgulf

HOW MADE

Recovered from trona ore or brine; synthesized from salt and limestone using ammonia

MAJOR DERIVATIVES (U.S.)

None accounting for more than 5% of consumption

MAJOR END USES (U.S.)

Glass 50%; chemicals manufacture 25%

FOREIGN TRADE

Exports—holding at about 1.5 million tons, imports—holding at about 20,000 tons in 1985

PRICES

List prices, after temporary voluntary allowances, \$79 per ton at plants in Wyoming

Despite being beset by problems relating to consumption, producers of soda ash are hanging in there. Major problems include a decline in their major U.S. market, barriers to export sales to various parts of the world, and high export selling prices because of the strength of the dollar in foreign trade. Nevertheless, soda ash production this year likely will be level with last year without a large increase in inventories.

The 1985 production total of close to 8.5 million tons a year may be a magic number for soda ash producers, having held at that level in 1983 and 1984 and likely to hold there through 1985. Small declines in demand in one or more uses of soda ash are being offset by small increases in demand by other uses or by exports.

The stall in demand and in production growth has minimized gains in profitability, capacity, and process development. Because 1985 will be another year in which demand will hold, no changes in any of these important industry factors are expected.

Pricing of soda ash continues under pressure as a result of its relatively large unused production capacity—especially the natural form recovered from trona ores mined in Wyoming. The net list price of \$79 per ton at plant sites for natural soda ash after a temporary voluntary allowance may have some holes in it as producers strive to maintain their markets in the face of competition from plastics as container materials.

Because of overcapacity, pricing pressures, and low profitability, few changes will come in 1985 for soda ash. No new mines or other basic production facilities will be announced. A shift to solution mining, once thought to be a source of major cost savings, apparently remains on hold.

Capacity to make soda ash continues at 11 million tons a year. This includes Allied's plant, which makes synthetic soda ash. The average plant operating rate will hold at about 77%,

if 1985 production meets the forecast total of 8.5 million tons.

Actual U.S. demand for soda ash will amount to 7 million tons in 1985 or slightly less. The rest of production, some 1.5 million tons, will be exported to many different countries.

Prospects would be good for an increase in exports of soda ash but for the strength of the dollar against foreign currencies. The strong dollar and high shipping costs are making U.S. soda ash less competitive in many world markets relative to soda ash produced in both Eastern and Western Europe. World demand, however, continues to grow, opening more markets that can be filled by U.S. soda ash rather than by European synthetic soda ash produced in obsolete plants.

In the U.S., more than half of soda ash consumption goes to make various kinds of glass. Container glass accounts for about two thirds of this; flat (architectural) glass, fiber, and miscellaneous glass uses take the other third. Container glass manufacture could require 2 to 4% less soda ash, or some 50,000 to 70,000 tons, than it did last year. Container glass and flat glass could be the two major markets declining in demand even in a year of continued economic growth.

The container glass market continues to be hurt by a shift toward plastic containers, particularly bottles, and by increased use of recycled glass or cullet. The bigger part of this loss will come from the switch to plastic bottles for beverages and foods. But the quality of cullet, and lack of nonglass items such as stones and metal in it, continues to improve, helping its recycling.

Other markets for soda ash, such as chemicals and pulp and paper manufacture, continue to grow, helping to offset losses in container uses. But these and some relatively fast-growing uses, such as desulfurization and other pollution control efforts, all are small when compared with the use in glass making, thus only partially replacing this market loss.

Drug firm earnings sluggish in fourth quarter

Some drug companies spent 1984 reorienting themselves to contain costs and deal with changes in the marketplace. Many sharply increased research and development spending in their quest for a revitalizing drug breakthrough. And almost all continued to be buffeted by the unprecedented strength of the U.S. dollar against foreign currencies. As a result, the pace of the pharmaceutical industry's earnings growth continued to slow in the fourth quarter of 1984. For the entire year, net income increased only modestly.

In fourth-quarter 1984, a group of 16 major pharmaceutical companies achieved a composite increase of just 3% in sales from fourth-quarter 1983 and a composite increase of 5% in net earnings. This lifted the composite profit margin for the group to 11.2% from 10.9% in fourth-quarter 1983. As has happened for several quarters in a row, G. D. Searle—still watching aspartame demand soar—turned in the most stellar performance, with sales up 18% and earnings up 22%. Continuing to perform weakly compared with its competitors was Baxter Travenol, whose sales dropped 4% and whose

income plummeted 61% in the quarter.

For the entire year, the group's sales rose 5% and net income rose 8% over 1983. Consequently, the overall profit margin moved up to 11.3% from 10.9% in 1983. As in the fourth quarter, the best performer in the group was Searle, with net income up a hefty 36%, and the biggest loser was Baxter Travenol, with earnings down a third.

For some time, the rising value of the dollar has cut into the revenues of the pharmaceutical industry, most members of which do a large portion of their business overseas. Baxter Travenol, for instance, says its international sales in the fourth quarter increased 1% over the year-earlier period, but would have risen 13% had foreign currency values remained at the average levels of the comparable period in 1983. Bristol-Myers says exchange rate fluctuations chopped \$145 million, or 4%, out of total sales for the year.

Because foreign currency values declined in relation to the dollar, the year's international sales at Eli Lilly were reduced \$63 million; at Merck, annual sales abroad were cut \$145 million; at Pfizer, worldwide

sales rose 6% in 1984 on a local currency basis, but only 3% when translated into dollars; at Revlon, total sales for the year were cut by \$125 million; at Schering-Plough, 1984 earnings were 33 cents less per share. If foreign currency values had remained steady, sales would have been \$75 million higher at SmithKline Beckman, and \$80 million higher at Sterling Drug.

At the same time that companies' earnings were being reduced by currency translation, firms were generally boosting R&D expenditures in their efforts to develop products for the newly cost-conscious health care market, to find new blockbuster drug products, and to compensate for the inroads made by generic copies of drugs with expired patents. For example, Abbott Laboratories, whose 16% rise in income was double that for the group for the year, increased its R&D outlay 19% to \$219 million in 1984. Also, last year the company completed the construction of two new facilities for pharmaceutical and diagnostics research.

Eli Lilly spent \$341 million on R&D in 1984, 16% more than the previous year, and completed a \$65 million biomedical research center at its corporate headquarters in

Pharmaceutical firms' earnings rose 5%, sales just 3% in fourth quarter

Companies	FOURTH-QUARTER 1984						FULL-YEAR 1984					
	Sales	Earnings ^a	Change from 1983		Profit margin ^b		Sales	Earnings ^a	Change from 1983		Profit margin ^b	
	(\$ millions)		Sales	Earnings	1984	1983	(\$ millions)		Sales	Earnings	1984	1983
Abbott Labs	\$ 850.3	\$123.1	6%	16%	14.5%	13.2%	\$3104.0	\$402.6	6%	16%	13.0%	11.9%
American Home Products	1105.7	166.5	4	13	15.1	13.9	4485.5	655.8	5	11	14.6	13.8
Avon Products	852.1	73.7	-12	5	8.6	7.3	3141.3	181.7	0	5	5.8	5.5
Baxter Travenol	460.0	22.6	-4	-61	4.9	12.2	1800.4	145.2	-1	-33	8.1	12.0
Bristol-Myers	1010.8	117.7	6	14	11.6	10.6	4189.4	472.4	7	16	11.3	10.4
Lilly	777.9	117.8	3	2	15.1	15.3	3109.2	490.2	2	7	15.8	15.1
Merck	961.9	115.6	12	10	12.0	12.3	3559.7	493.0	10	9	13.8	13.9
Pfizer	966.3	129.3	-1	8	13.4	12.3	3854.5	507.9	3	14	13.2	11.9
Revlon	639.3	33.3	0	-10	5.2	5.8	2399.2	112.1	1	1	4.7	4.7
Schering-Plough	448.1	37.7	3	4	8.4	8.3	1874.3	177.2	4	-1	9.5	9.9
G. D. Searle	334.3	53.3	18	22	15.9	15.3	1245.8	161.6	32	36	13.0	12.6
SmithKline Beckman	766.2	120.7	7	3	15.8	16.4	2949.2	500.3	4	3	17.0	17.1
Squibb	523.7	49.8	10	15	9.5	9.1	1886.0	144.9	7	14	10.5	9.8
Sterling Drug	457.5	36.2	-2	5	7.9	7.4	1827.3	144.9	-1	8	7.9	7.3
Upjohn	523.6	33.9	4	0	6.5	6.7	2179.1	173.3	10	8	8.0	8.1
Warner-Lambert	793.5	51.2	1	6	6.4	6.2	3166.7	223.9	2	12	7.1	6.5

a Excludes significant extraordinary and nonrecurring items. b After-tax income as a percentage of sales.

Business

Indianapolis. At Pfizer, R&D spending totaled \$252 million for the year, up 11% from 1983. Searle spent \$120 million on R&D, 15% more than it did in 1983. At Baxter Travenol, on the other hand, spending on R&D moved up just 3% in 1984.

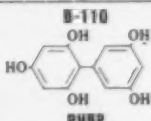
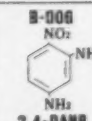
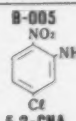
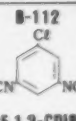
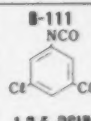
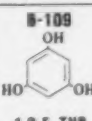
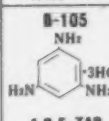
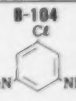
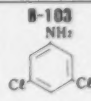
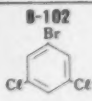
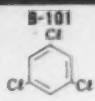
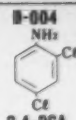
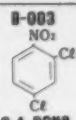
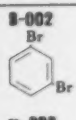
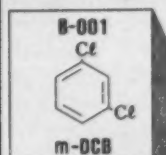
For the most part, the chemical units of pharmaceutical companies outperformed the corporation as a whole. At Avon Products, for instance, which reversed a four-year decline with an overall 5% earnings increase in 1984 on flat sales, the Mallinckrodt division had 1984 sales of \$541 million, up 5%, and operating profit was up 5%. If the company had restated 1983 results to reflect the November 1983 divestiture of Mallinckrodt's food ingredients business, the division's operating profit would have increased 13% in 1984. Eli Lilly's agricultural products sector reported worldwide sales of \$757 million in 1984, up 4%. Of the sector's two chief segments, agricultural chemicals had \$423 million in sales, up 12%, whereas animal health products sales, hurt by increased competition and the dollar, declined 4% for the year.

At Sterling Drug, the chemicals and other products segment recorded 1984 sales of \$145 million, up 6% from 1983, and a 1984 operating profit of \$8.8 million, up 21% from 1983. By comparison, the company's consolidated sales declined 1% and operating profit rose just 5% for the period. Merck also reports year-to-year gains in sales for its specialty chemical and environmental products segment. Pfizer, on the other hand, which recorded a 3% sales gain overall, says its specialty chemicals sales dropped 4% in 1984. The decline would come to just 1%, however, if the financial statement excluded results of the Greensboro, N.C., plasticizer operation the company divested in December 1983.

Most companies continued to cut costs where possible. Baxter Travenol, for example, says it cut operating expenses 2% last year. Nevertheless, Moody's Investor Service lowered its ratings on Baxter Travenol's long-term debt last month, citing concern about the company's ability to match past operating results in the coming years.

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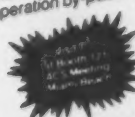
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Sprayed-on asbestos-containing insulation coats ceiling beam. Such friable material, often seen exposed in parking garages, crumbles easily.

ASBESTOS

The fiber that's panicking America

Pamela S. Zurer, C&EN Washington

March 1984—The Environmental Protection Agency assesses a \$24,000 fine against three schools in Goffstown, N.H., for failing to comply with EPA's rule concerning asbestos in schools.

December 1984—The District of Columbia files a \$400 million lawsuit against asbestos manufacturers and distributors to recoup the cost of removing asbestos from city buildings.

January 1985—Fairfax County, Virginia, government announces it will spend \$5 million to \$6 million to remove asbestos from three public buildings, even though it says air levels are not hazardous.

Demand for asbestos in the U.S. last year was only about 30% of what it was at its peak in 1973. Fear of the material's toxicity and the health-related lawsuits it has engendered are largely to blame. But demand has been mushrooming for the services of the asbestos abatement industry, as property owners rush to remove asbestos

that was used as fireproofing and insulation in many buildings built before the mid-1970s. Demand for legal expertise is increasing, too, with property damage suits multiplying rapidly.

Two decades ago, concerns about asbestos hazards centered on workers who had been exposed to huge amounts of fibers in their jobs. In the 1960s, landmark epidemiological studies by Irving J. Selikoff of Mount Sinai School of Medicine and E. Cuyler Hammond of the American Cancer Society showed that insulation workers who had dealt with asbestos for 20 years or more were dying of cancer and the complications of asbestosis at alarming rates. Later, a few people whose only contact with the material was that they lived in the same house as asbestos workers were found to be dying of mesothelioma—a rare cancer of the lining of the lung or abdomen.

In 1971, asbestos became the first material to be regulated by the then-new Occupational Safety & Health Administration. In 1982, lawsuits filed by workers suffering from asbestos-related diseases led Manville Corp.—once the largest U.S. asbestos producer but since

1983 out of that business—to look for an escape from the rising costs in bankruptcy court.

Today, although there is still concern that people who work with asbestos are not protected adequately, fear is mounting over the long-term effects of exposure to asbestos in the general environment. Asbestos fibers can be found in the air almost anywhere if you look hard enough. Sources of asbestos in outdoor air range from natural rock to mining and manufacturing operations to particles released from the brake linings of cars and trucks. Indoors, aging or damaged building materials can release asbestos into the air.

Anxiety over asbestos in buildings began to grow in earnest last spring when the Environmental Protection Agency started highly publicized efforts to enforce its asbestos-in-schools rule. That regulation requires school administrators to inspect their buildings for asbestos-containing materials that crumble easily. If any is found, the schools must notify employees and parents that friable asbestos is present. EPA doesn't require that the material be removed, because the mere presence of asbestos is not necessarily hazardous, but recommends each school be evaluated on a case-by-case basis.

Telling parents that there is asbestos in their children's school but authorities aren't going to do anything about it, however, is like saying there's dynamite in the basement but there's no need to worry because the fuse isn't lit. Many parents have been frightened by statements that breathing a single fiber of asbestos can cause cancer years later. Panic and pressure ensue, and the result in many cases has been school closings and hasty removal of asbestos.

Similarly, asbestos is being taken out of many private and public office buildings. Often owners are motivated by fear they will be held liable for future asbestos-related diseases in the buildings' occupants. The bill for all this ripping out of asbestos may come to \$20 billion, a staff member of the House Appropriations Committee estimates.

Yet no one is really sure how hazardous low levels of asbestos in the air are. And asbestos removal is a complicated task that, if done improperly, can leave higher air levels of asbestos in the building than existed before the work started.

Evaluating the risks that asbestos poses to the general population requires extrapolating data gathered in the workplace, where approximate fiber levels are known, to a much larger group of people exposed to much lower concentrations that are essentially unknown. Unlike the case with many toxic chemicals, a large amount of information on occupational hazards of asbestos is available. Even with that massive body of literature, however, it is very difficult to pin down accurately the risks to people who are exposed outside the workplace.

For example, last year a National Research Council (NRC) Committee on Nonoccupational Exposure to Asbestiform Fibers tried to quantify the risks of inhaling low levels of asbestos. The panel concluded that breathing the asbestos present in ambient air may be hazardous and some deaths from cancer probably will result. In contrast, a Canadian report by the Royal Commission on Matters of Health & Safety Arising from

the Use of Asbestos in Ontario, also issued last year, finds "no evidence that disease afflicts individuals who breathe asbestos in outdoor air or inhale it as occupants of asbestos-containing buildings."

Although the NRC panel's stated conclusions are considerably more alarming than those of the Canadian group, the NRC committee states in the body of its report that the number of deaths expected to result from nonoccupational exposures to asbestos are very uncertain. In fact, in calculating the quantitative risks of developing cancer from such exposures to asbestos, the NRC panel estimated the risk could be as high as 1700 per million or could be nil.

"You must realize you can't pin down any specific numbers within that range," says committee member Jeremiah Lynch, manager of industrial hygiene for Exxon Chemical. As with all quantitative risk assessments, so many assumptions were necessary that the panel found it impossible to be exact.

Because of the weight a report from the prestigious NRC can carry with policy makers struggling to regulate asbestos, it's important to look at all the ifs, ands, and buts of the study. "A danger we all recognized when we worked on this was that people will overlook all the qualifiers," Lynch says.

Risk assessment complications

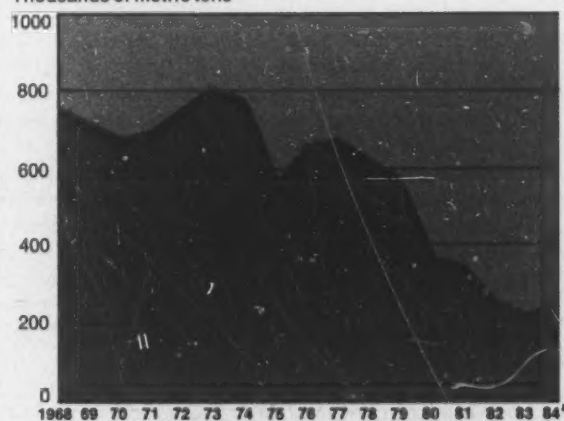
To assess the health risk of a substance, its toxic effects must be identified, the relationship between dose and disease clarified, and the dose the population is exposed to determined. Uncertainties abound at every step.

In the case of asbestos, the toxic effects of high exposures are well documented. Among them are asbestosis, a type of pulmonary fibrosis or scarring of the lungs. Victims become short of breath and may eventually struggle so hard to breathe that they die of heart failure.

Asbestosis, which may develop after years of intense

U.S. consumption of asbestos peaked in 1973

Thousands of metric tons



* Estimate. Source: Bureau of Mines

What's in a name? Even defining asbestos is difficult

Asbestos is not a discrete chemical compound or even a single group of minerals. The term is an imprecise commercial one that refers to several fibrous inorganic materials that are valued in industry for their high tensile strength and resistance to heat.

Unfortunately, sometimes minerals that do not meet mineralogists' criteria for asbestos also are lumped under the collective term. With medical scientists, federal regulators, industrial hygienists, contractors, unions, school boards, and even parent-teacher associations trying to tackle the problem of indoor exposure to asbestos, imprecise definitions only make a complicated problem even more difficult to handle.

The several mineral forms that are known commercially as asbestos vary in composition, fiber size, and crystal structure. They share what mineralogists call the "asbestiform habit"; that is, under certain rare conditions the minerals crystallize in bundles of hundreds or thousands of strong, flexible fibrils that look like organic fibers. However, the same minerals can—indeed usually do—crystallize in nonfibrous, rocklike forms.

Other minerals (for example, talc) also may sometimes form fibers under certain geological conditions. These fibers ought not to be called asbestos, mineralogists argue, because they lack the unique flexibility and tensile strength of true as-

bestos varieties. Asbestos fibers tend to cleave along the long axis of the fiber, yielding the thinner component fibrils, rather than break across the fiber axis into shorter lengths.

All commercial varieties of asbestos are silicates, that is, minerals where SiO_4 tetrahedra form the backbone of the crystal lattice. Silicate minerals are classified according to their crystal structures. Asbestiform mineral varieties occur as members of two groups: the serpentine and amphibole minerals.

Only one commercial asbestos mineral, chrysotile, belongs to the serpentine group. Serpentine is a magnesium silicate, in which layers of linked silica tetrahedra alternate with layers of magnesium oxide-hydroxide octahedra. In serpentine rock, the double layers result in platy crystals that tend to cleave into sheets like mica. In the asbestiform variety, however, the double layer rolls up on itself, curling as it grows to form long hollow tubes that are characteristic of chrysotile.

Chrysotile asbestos also is called white asbestos. Most asbestos being produced today is chrysotile, primarily from Canada and the U.S.S.R.

The other types of commercial asbestos all belong to the amphibole mineral group. Amphiboles are characterized by

Some silicates can crystallize as asbestos fibers

Mineral name	Chemical formula	Asbestiform variety
SERPENTINE GROUP		
Serpentine	$\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$	Chrysotile (white)
AMPHIBOLE GROUP		
Riebeckite	$\text{Na}_2\text{Fe}_3^{2+}\text{Fe}_2^{3+}\text{Si}_8\text{O}_{22}(\text{OH},\text{F})_2$	Crocidolite (blue)
Cummingtonite-grunerite	$(\text{Mg},\text{Fe}^{2+})_7\text{Si}_8\text{O}_{22}(\text{OH})_2$	Cummingtonite-grunerite (amphibole, brown)
Tremolite-actinolite	$\text{Ca}_2(\text{Mg},\text{Fe}^{2+})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$	Tremolite-actinolite asbestos
Anthophyllite	$(\text{Mg},\text{Fe}^{2+})_7\text{Si}_8\text{O}_{22}(\text{OH},\text{F})_2$	Anthophyllite asbestos

Source: Bureau of Mines

exposure, was the first toxic effect of asbestos to be uncovered. Early occupational standards were designed to protect workers from that disease.

"Asbestosis occurs, for all practical purposes, only after exposure in the workplace," says Arthur M. Langer, a mineralogist who is associate director of the environmental sciences laboratory in Mount Sinai School of Medicine and a member of the NRC panel. The committee did not try to quantify the risk of asbestosis in its report on nonoccupational hazards, as it considered such risks in the general population to be nil.

Epidemiological studies have shown that occupational exposure to asbestos also can produce lung cancer, frequently occurring after a latency period of 10 to 30 years. Hammond and Selikoff documented that smoking cigarettes multiplies the risks of developing lung cancer from asbestos exposure. Lung cancer in asbestos-exposed workers could be cut significantly if they did not smoke cigarettes.

Mesothelioma is a very rare, always fatal, form of cancer of the lining of the lungs and abdominal cavity. The National Cancer Institute estimates there are only about 970 cases a year in the U.S. It is often called a

"marker disease" for asbestos because most cases develop 20 to 40 years after exposure to that material.

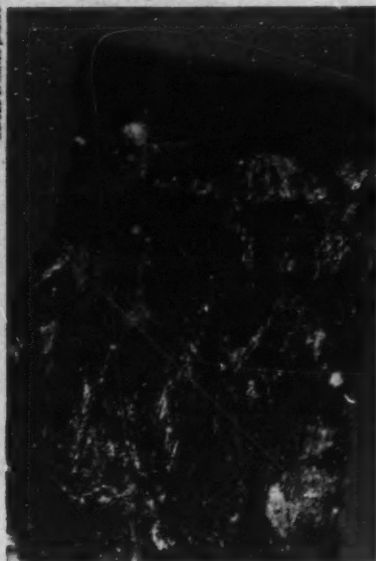
However, in 10 to 30% of all mesothelioma victims no exposure to asbestos can be documented. Nevertheless, most researchers believe there would be few cases of mesothelioma in the absence of asbestos exposure.

Unlike lung cancer, the risk of developing mesothelioma is not tied to smoking. However, the risk seems to increase with the amount of time that passes after an individual is first exposed. That is what makes parents so fearful for their children's health. For if it takes, say, 40 years to develop mesothelioma, a child exposed to asbestos at age 10 would be more likely to get that cancer before dying of something else than an adult exposed at age 25.

Dose-response curves

The health risks of breathing high amounts of asbestos fibers are clear. What is less certain is the relationship between the amount of fiber inhaled and the amount of disease—that is, the dose-response curve.

Some occupational studies have complete enough data on dose levels to indicate that the risk of disease drops



Minerals that under certain geological conditions crystallize as asbestos fibers more often form typical rocks. Cummingtonite (right) is the mineral that may sometimes crystallize as asbestos fibers known as amosite (left)

strips of cations (usually calcium, sodium, magnesium, iron, or aluminum) sandwiched between two strips of linked silica tetrahedra. All the amphiboles have about the same basic structure but are substituted with different cations. Amphibole strips of asbestos are thought to grow in single crystal whiskers, often in veins of massive nonfibrous rock

Only two amphiboles have been ex-

ploited commercially as asbestos to any significant degree. Crocidolite (blue asbestos), the asbestiform variety of the mineral riebeckite, currently is mined only in South Africa. Cummingtonite-grunerite asbestos (brown asbestos)—produced only in the Transvaal province of South Africa—is often called amosite from the acronym for the company Asbestos Mines of South Africa. Other amphiboles, such

as anthophyllite and the tremolite-actinolite series, also occur in asbestiform varieties, but only rarely.

Further complicating matters is that minerals rarely occur as their pure, ideal composition but may contain a wide variety of contaminant ions. Batches of chrysotile from different mines, for example, are never identical.

Mineralogists themselves differ on the details of defining asbestos. But the fine points are even more likely to be obscured when the term asbestos is used by medical scientists or regulatory agencies. For instance, the legal regulatory definition of asbestos created by the Occupational Safety & Health Administration in setting occupational exposure limits is broader than the definition mineralogists and some other government agencies prefer. OSHA defines the minerals chrysotile, crocidolite, amosite, and all forms of anthophyllite, tremolite, and actinolite as asbestos.

"OSHA's terminology is so broad it includes a great deal of Earth's crust," says Malcolm Ross, mineralogist with the U.S. Geological Survey. OSHA is considering modifying its definition by adding the word "asbestiform" in front of anthophyllite, tremolite, and actinolite. That would bring OSHA's practice into line with the Mine Safety & Health Administration and the Consumer Product Safety Commission.

with decreasing exposure to asbestos. But there is no evidence in occupational studies to show there is a threshold level below which there are no adverse effects. "The problem is we haven't observed any safe levels," says Langer.

Some researchers think there are no safe levels of asbestos in the air. "As long as there's any exposure, there will be illness," says Selikoff. Accordingly, in formulating its report, the NRC committee chose to make the conservative assumption that no threshold level exists below which there isn't any risk of developing lung cancer or mesothelioma from asbestos.

Another problem in establishing a dose-response curve is the inaccuracy of old dose measurements. "We can't even be sure what was in the workplace 30 years ago," Langer says. "We only have good measurements since 1972," when OSHA began requiring them.

The shape of the dose-response curve at low doses isn't known and must be extrapolated from the high occupational exposures. "When extrapolating down to zero dose you must be careful," Langer says. "You are going beyond the hard data and extrapolating through doses for which no biological data are available."

As is often done in estimating the environmental risks of carcinogens, the NRC panel assumed the response was linear. This again is a conservative assumption that tends to overestimate the incidence of cancer at low doses.

The most controversial assumption in the NRC report is the panel's decision to lump together all forms of asbestos. The term asbestos is a commercial one that includes a number of mineral varieties that crystallize as strong, flexible fibers. A very vocal minority asserts that the type of asbestos most commonly used in the U.S., chrysotile, causes significantly less mesothelioma than other forms of asbestos, known as amphiboles. By grouping all the types together, these critics charge, the overall risks from asbestos are exaggerated.

"The [NRC] report is dangerous," says Andrew Churg, a pathologist at the University of British Columbia. "It ignores the difference between chrysotile and the amphiboles so it makes the mesothelioma risk seem much higher." Churg thinks the Canadian report, which cites only a weak association between chrysotile fibers and mesothelioma, is more accurate.

Churg's opinion is shared by others who object to the different species of asbestos being classed together.

Malcolm Ross, a mineralogist with the U.S. Geological Survey, has made something of a crusade of his belief that chrysotile is not a significant health threat in a nonoccupational setting.

"When the public is led to believe that only the tiniest bit [of asbestos] will kill them, they're going to demand its removal," Ross says. "I'm troubled about where we are putting our money relative to the risks."

Ross says that to estimate accurately the health effects of each kind of asbestos separately, epidemiologists must look at the experience of asbestos miners and millers. He points specifically to chrysotile miners at Thetford Mines in Quebec. An epidemiological study of about 11,000 miners there by J. Corbett McDonald of McGill University found very few deaths from mesothelioma. In contrast, other studies have shown up to 10% of workers exposed to the amphibole called crocidolite die from mesothelioma.

The view that chrysotile asbestos is much less hazardous than the amphiboles forms the basis for regulation of asbestos in the U.K. and other members of the European Economic Community, where occupational standards allow higher levels of chrysotile than the amphiboles. The recent Ontario report recommends banning amphibole asbestos in Ontario, but not chrysotile. (The Canadian province of Quebec is a major producer of chrysotile asbestos; Ontario is not.) But in the U.S., Ross' position invites heated reaction.

"There's not a shred of evidence that some forms are less hazardous than others," Selikoff says. He points to a new study by Churg as the "smoking gun" that proves chrysotile is just as deadly as other forms of asbestos when it comes to mesothelioma. Churg and his co-workers found that of 90 chrysotile miners autopsied between 1980 and 1983, six died of mesothelioma.

Churg himself, however, says his data should not be used to judge the incidence of mesothelioma. "These are selected autopsies," he says. "You have to conclude that chrysotile ore causes mesothelioma, but it's very dangerous to draw conclusions on incidence" because the autopsies are not a representative sample.

Even though there are substantially fewer deaths from mesothelioma tied to chrysotile, the NRC panel decided not to weigh the risk of the various forms of asbestos separately. That is largely because, considering smokers and nonsmokers together, the most common kind of cancer associated with asbestos is lung cancer, and chrysotile appears to be just as potent in causing lung tumors as the other types of asbestos. However, the risk of lung cancer in nonsmokers, according to the NRC panel, is less than that of mesothelioma.

"I think that Ross' basic assertion that the amphibole asbestos minerals produce more mesothelioma is correct," says committee member Langer. "But that doesn't mean chrysotile is a safe fiber. The lung cancer rate in some industries that use this fiber is very high. We still have to contend with it."

Langer also suggests that different disease rates experienced by miners as compared to industrial workers may be caused by variations in fiber properties. "The physical dimensions and surface characteristics may vary from industry to industry," he says, "and these may be important factors in chrysotile asbestos's differential toxicity." The Canadian report also notes differences in disease rates in different industries.

Exposure measurements

The nature of the fiber is only one factor in gauging the risk of low-level exposure to asbestos. Just as important are the intensity and duration of exposure. Measuring the amount of asbestos in ambient air is not a trivial problem, however. Neither is relating ambient air levels to the amounts of asbestos found in occupational settings.

Asbestos levels in the workplace are measured as the number of fibers in a given volume of air. For instance, OSHA's permissible exposure limit currently is two fibers of asbestos per cubic centimeter of air.

OSHA counts the number of fibers more than 5 μ m long and at least three times longer than they are wide, using an optical microscope. Most fibers—perhaps 95%—in an occupational air sample are shorter than 5 μ m, but OSHA reasons the longer fibers are a fair index of the entire amount.

The light microscopy technique normally used in occupational settings is phase-contrast microscopy. "It allows you to visualize materials with a long aspect ratio (ratio of length to width) that are greater than 0.2 μ m in width," says John A. Small, a research chemist with the National Bureau of Standards. "But it doesn't distinguish among fibers of different origins. Under the phase-contrast counting methodology, glass, cellulose, and carbon fibers may be counted as asbestos," he says. Despite that limitation, phase-contrast microscopy is not a bad technique for an asbestos mill or plant, where one can reasonably assume that most of the fibers in the air are asbestos.



U.S. Geological Survey photo

Sources of asbestos fibers in ambient air include natural rock. Rock outcrops near this park north of Coalinga, Calif., have been estimated to contain up to 50% short-fibered chrysotile asbestos

However, it was discovered early on that measuring asbestos in ambient air is very difficult. "It's a problem of a needle in a haystack," says Exxon's Lynch. "You find a little bit of asbestos in the presence of an enormous amount of particulate matter."

Therefore, electron microscopy techniques are used to measure asbestos accurately in ambient air. Samples are collected and treated to remove organic materials. Clumps of fibers are broken up so that the individual submicron-sized fibers can be seen. Transmission electron microscopy (TEM) can give the crystallographic structure of a fiber to distinguish asbestos from other fibers.

TEM is the definitive technique for measuring asbestos in ambient air but it costs \$300 to \$500 per sample. In addition, not many labs are set up to do that kind of analysis. "[Fewer] than 20 labs in the country have the combination of equipment and experience to do TEM," says Ian M. Stewart, vice president of McCrone Environmental Services, part of Walter C. McCrone Associates, a microscopy firm based in Chicago.

For that reason, scanning electron microscopy (SEM), which is cheaper and more accessible, is often suggested as a substitute for TEM. But Small and Stewart think the ability of SEM to distinguish chrysotile fibers is limited because of poor contrast.

In either electron microscopy technique, the number of fibers seen does not reflect the number in the original sample, because the sample preparation techniques break up the fibers. Therefore, the results are expressed as the mass of asbestos per volume of air.

Ambient air levels

Out in the country, away from man-made or natural sources of asbestos, there is less than 0.01 ng of asbestos per cubic meter of air, estimates William J. Nicholson, a physicist who is associate director of the environmental sciences laboratory at Mount Sinai School of Medicine. "But in a typical urban environment, there's about 3 ng per cu m over 24 hours," he adds. In the 1970s, concentrations of asbestos in New York City air ranged from 20 to 60 ng per cu m. Asbestos in outdoor air in cities probably stems from construction and remodeling or demolition work on buildings and from car brakes.

In 1978, Nicholson measured the levels of asbestos inside 10 schools that contained visibly damaged asbestos building materials. The concentration of chrysotile ranged from 9 to 1950 ng per cu m. Other studies have found asbestos air levels inside buildings with asbestos-containing materials ranging from 1 to more than 500 ng per cu m.

Judging whether these low concentrations of asbestos are a health risk requires relating them to the higher levels that epidemiologists found were hazardous to workers. Unfortunately, the occupational doses are measured in fibers per volume of air, whereas ambient air levels are measured in mass per volume of air. Accurately interconverting the two types of measurements is virtually impossible.

"The fibers suspended in ambient air are different from those in an occupational setting, not only in concentration but in size distribution," Lynch says. "Vir-



Asbestos abatement worker on the job last summer in Maplewood, N.J., elementary school

tually all of the fibers [in ambient air] are small." That means that a nanogram of asbestos from the workplace might contain 2000 relatively large fibers, but the same mass in ambient air might be made up of 70,000 smaller fibers, to use an example from the NRC report.

However, the NRC panel decided to interconvert the exposure measurements from the two environments by assuming that the mass of an asbestos fiber found in the ambient air was equivalent to the mass of a fiber, of a particular dimension, found in the workplace. That assumption underestimates the number of fibers in ambient air and overestimates their size.

And that assumption also introduces a huge uncertainty in the panel's risk assessment, because fiber size has been hypothesized to be related to asbestos's toxicity. "That's why the lower limit of our risk assessment is zero," says Lynch. "Longer fibers are definitely toxic, but some researchers say that short fibers have no activity."

Some animal experiments indicate that shorter-length particles have little carcinogenic effect, perhaps because they are small enough to be cleared by macrophages. "However, the majority of the NRC committee does not agree that small fibers are totally inactive, although they may be less toxic," Lynch says. "It just isn't known." In contrast, the Canadian report concluded that thin asbestos fibers longer than 5 μm are hazardous.

Qualitative risk assessment

Using all of these assumptions, the NRC committee calculated the risks of developing mesothelioma and lung cancer from breathing asbestos in the ambient air over a lifetime. The panel calculated that at an exposure level of 0.0004 fiber per cc—about the level of asbestos

Underlying cause of asbestos's toxicity still unclear

"Everyone's got an interesting theory and there are data sets to support each and every one. But when you come down to the essentials—that is, what is it about asbestos that imparts its activity—your guess is as good as ours," Arthur M. Langer of Mount Sinai School of Medicine told federal officials last fall. The group was gathered for a briefing on the National Research Council's report on nonoccupational health risks of asbestiform fibers.

Although the state of scientific knowledge isn't quite so bad as Langer's remark implies, there's remarkably little that can be said with certainty about the root of asbestos' toxicity. Epidemiological studies indict asbestos as causing pulmonary fibrosis (asbestosis), lung cancer, mesothelioma (cancer of the lining of the lung and abdomen), and perhaps gastrointestinal cancer in workers exposed to large amounts in their jobs.

But only a few clues have yet been uncovered to link the physical and chemical properties of the various forms of asbestos to their biological activity. For example, it's not clear if the same properties trigger all the health effects or whether a different characteristic is responsible for asbestosis, say, than for lung cancer.

Important details that could help tie specific characteristics of asbestos fibers to disease are often missing from epidemiological studies that span several decades. Records of the exact types, origins, dimensions, and fiber concentra-

tions of asbestos that workers were exposed to years ago may never have been kept or may have been lost. And inaccurate use of mineralogical terms in the scientific and medical literature prevents precise characterization of exposure.

More recent experiments in animals and in tissue culture—where conditions can be carefully controlled—overcome some of these difficulties. Interpreting such studies and extrapolating the conclusions to humans can be controversial, however.

The cellular mechanisms underlying asbestos's carcinogenicity are being explored. The multistage theory of cancer holds that two steps are necessary in the development of cancer. In the initiation step, DNA in a cell is damaged or mutated. In the promotion step, the altered cell is encouraged to divide and proliferate.

Although the evidence is contradictory, most laboratory studies show asbestos fibers don't damage DNA. Therefore, asbestos has not been shown experimentally to be an initiator of cancer.

Both laboratory and epidemiological studies point to asbestos's role as a promoter of lung cancer, however. For instance, asbestos exposure multiplies the risk of lung cancer from cigarette smoking. There also is evidence that asbestos may help carry certain carcinogenic hydrocarbons into cells. In addition, interaction of asbestos fibers with cell membranes favors the release of substances important to the carcinogenic process.

A key determinant of asbestos's tox-



Crocidolite fibers in hamster respiratory tract. Small spherical cells are macrophages

icity may be fiber size. The fiber has to reach the lung before it can do damage. "Fibers above a certain diameter are not even inhaled," says Brooke T. Mossman, associate professor of pathology at the University of Vermont and a member of the committee that prepared the NRC report. Those over about 3 μ m in diameter probably are screened out by nasal hairs or other protective mechanisms in the upper respiratory tract.

Some researchers think that very small asbestos fibers also may not be toxic, although the NRC panel concluded no minimum size of fiber could be declared not to have any effect on health. Short il-

lness in New York City air, according to the conversion factor the panel chose—the risks of developing mesothelioma range from zero to 350 per million.

At any exposure level, the risk of developing lung cancer depends on an individual's sex and on whether he or she smokes. The greatest risk is to male smokers, ranging from zero to 290 per million. Female non-smokers were calculated to have the lowest risk, ranging from zero to 13 per million.

The committee also calculated the risk of a lifetime of exposure at a higher level, equivalent to the level that might be found in buildings with asbestos surfaces. Those risks ranged from zero to 1700 per million. The Canadian report, however, states that "asbestos in building air will almost never pose a health hazard to building occupants," unless elevated exposure is caused by disturbing the asbestos.

"There's an enormous amount of uncertainty" in as-

sessing the risks of asbestos fibers in ambient air, Nicholson says. "The fibers are measured in so many different ways. There's the possibility of differential toxicity. The fiber dimensions are different in different environments." Nicholson recently prepared assessments of asbestos health risks for EPA and OSHA. His quantitative risks findings are generally in the same ballpark as the NRC panel's.

"In all of these decisions we state our assumptions," says panel member John Van Ryzin, professor of biostatistics at Columbia University. "I was very insistent that we report what our uncertainties are."

The NRC panel's charge was to assess the risk from nonoccupational exposures to asbestos, not to recommend what to do about them. Yet the uncertainties inherent in calculating risk mean policy makers have difficult decisions ahead in tackling how to manage asbestos exposure.

bers may be breathed in and out without settling to any great extent in the lungs. More important, however, is that the body's system of defense against foreign matter may cope with short fibers better.

"Macrophages can swallow short fibers and transport them out of the lung," Mossman says. The cilia of the cells lining the trachea can sweep the engulfed fibers up to eventually be coughed out, spit out, or swallowed. Some may stay in the body, traveling to the lymph nodes, but there is no direct evidence that this causes disease, Mossman says.

Fibers of intermediate size, thin enough to enter the lung but too long to be entirely surrounded by macrophages, may be a culprit. In fact, one theory holds that it is the long, thin dimensions of asbestos fibers, rather than any specific chemical property, that it is the key to their toxicity.

That notion, known as the Stanton hypothesis, grew out of experiments performed by the late Mearl F. Stanton and coworkers at the National Cancer Institute. They inserted fibers of different sizes and types—the major forms of asbestos as well as other, nonasbestos fibers—into the lining of the lungs of rats. They concluded that the factor most tied to mesothelioma in their experiments was a particular size of fiber (specifically, fibers less than 0.25 μm in diameter and longer than 8 μm), rather than a particular chemical composition. Besides the various types of asbestos, fibers of borosilicate glass, potassium titanate, and some aluminum compounds caused mesothe-

lioma in the rats when the fibers fit the key dimensions. Other researchers have found that silicon carbide fibers and some naturally occurring zeolite fibers cause mesothelioma in similar experiments.

If size and shape, rather than chemistry, control the carcinogenicity of fibers, any proposed substitutes for asbestos need to be studied very carefully. For example, epidemiological studies of workers exposed to fibrous glass have shown a small increase in respiratory cancer. Until about 10 years ago, however, most glass fibers were larger than the size implicated in Stanton's studies. It may be too soon for any adverse effects from the thinner, more recently introduced glass fibers to show up.

The Stanton hypothesis is not without its critics, however. For one thing, it is experimentally difficult to completely separate fibers by size. A batch of fibers nominally of one length can contain fibers of quite different sizes. And milling minerals to reduce their length also can profoundly change their crystallinity and surface characteristics, says Langer.

Other workers have statistically re-examined Stanton's work with different results. French researchers conclude that the ratio of length to width (known as the aspect ratio) is most important and that it is not possible to separate the effects of length and width. Langer recalculated the data for crocidolite and judged fibers 4 to 8 μm long were most toxic, rather than those longer than 8 μm .

"Fiber dimension may be very important," Langer says, "but other factors are at least as important. You cannot dismiss

surface chemistry." Langer and graduate student Robert P. Nolan have been studying how minerals communicate with cell membranes through information on the mineral surface.

"Morphology may be important in getting the fiber to the site where it does damage," Langer says. "But once at the target site, surface characteristics take over. The nature of the chemical functionalities, their spacing, number, and geometrical configuration on a mineral surface are all going to affect how that mineral communicates and therefore interacts with a cell," he adds.

The question is more than academic. If surface chemistry is the key, then there would be a rational basis for the argument that certain forms of asbestos are less toxic than others. Some scientists believe, on the basis of epidemiological studies, that chrysotile fibers produce far less mesothelioma than crocidolite or amosite, although the issue is hotly debated.

If certain chemical functionalities could be pinpointed as the bad actors in asbestos toxicity, in theory modifications to the surface could result in less hazardous forms of asbestos. For instance, a Canadian government-industry organization called Société Nationale de l'Amiante is supporting research in Langer's lab and elsewhere on a modified phosphorylated chrysotile. "So far, the phosphorylated fiber appears to have far less membrane activity as compared to untreated fibers," Langer says. "The implications of producing a safe fiber are of vast pragmatic importance. The concept and work are exciting."

For the government to regulate a substance, it must first determine that the material poses a hazard. Then federal agencies must decide if they can take steps to reduce or eliminate the risks.

In the case of asbestos, there is clearly an occupational hazard to workers. OSHA currently is trying to lower the permissible exposure level in the workplace to either 0.5 or 0.2 fiber per cc.

The Consumer Product Safety Commission banned the use of asbestos in spackling compounds and artificial embers for fireplaces in the mid-1970s. A few years later, manufacturers voluntarily removed asbestos insulation from hair dryers after CPSC began an investigation.

EPA has the authority to ban hazardous chemicals and mixtures under the Toxic Substances Control Act. In the 1970s, it forbade further use of sprayed-on asbestos materials as a hazard both to the workers applying the material and to people near the construction site. That

use of asbestos had become a popular method of fireproofing and insulating steel girders.

In 1983, EPA began drafting regulations to ban immediately some other uses of asbestos—including cement pipe and flooring and roofing products—and to phase out the rest over a 10-year period. But in early 1985, the agency said that, under TSCA, it must give other federal agencies a chance to regulate hazardous substances before it acts. So EPA has turned over its proposed ban on asbestos to OSHA and CPSC.

That move has angered critics in the environmental movement and trade unions and even within EPA itself, who suggest the action is simply an attempt by the Reagan Administration to stall further regulation of asbestos. However, if OSHA and CPSC don't move on the issue, the problem will end up back at EPA.

Yet some who are concerned about exposure to asbestos aren't sure that a ban on the material addresses the

Asbestos abatement requires multidisciplinary teams

The costs of removing asbestos from buildings are enormous. Estimates for, say, taking ceiling insulation out of an average-sized elementary school can run from \$100,000 to more than \$1 million. The expense stems from the time and expertise needed from professionals in many different areas if the job is to be done properly.

When a building owner decides to have asbestos removed from a property, there often is only a potential hazard from asbestos that might be disturbed at a later date. But once the abatement project begins, there is an immediate hazard to the workers involved. And if the cleanup is not done with great care, there may be real danger to the occupants who return to a supposedly safe building.

"An asbestos removal project is really a demolition project that leaves the building standing," says Roger G. Morse, a Troy, N.Y., architect whose firm specializes in asbestos work. "At the same time, there's potential for contaminating the whole building. You need people who know what they are doing watching over the whole thing."

The asbestos abatement industry is growing by leaps and bounds and the potential for problems from shoddy work is growing with it. For example, many local

governments are required by law to award contracts to the lowest bidder. "It's sometimes difficult to eliminate guys who don't know what they're doing," says Morse. "All it takes for a contractor to set up is \$20,000 to buy equipment."

"It's a new industry evolving more quickly than government can regulate it," says Brent W. Schopfel of Archway Contracting Co., Pennsauken, N.J. Schopfel is a charter member of the National Association of Asbestos Abatement Contractors, a nonprofit trade association formed in January 1984 to try to set standards for the industry.

In addition to the contractor whose workers actually will take out the asbestos, a removal project requires, at a minimum, an architect or engineer to draw up specifications and coordinate the work as well as an analyst and air-sampling laboratory to monitor fiber levels. Every employee must be trained in safe work practices, and the Occupational Safety & Health Administration requires they be given physicals at regular intervals.

Before the work can start, the contractor must notify local and state agencies and the Environmental Protection Agency, Schopfel says, and then wait the required period to give them time to respond. Next, the work site is sealed,

usually with plastic sheeting, to make a closed environment.

Decontamination facilities are built, including a shower and change room isolated by airlocks so employees don't carry fibers outside and home on their bodies or clothes. Another airlock is used to load the asbestos waste onto a truck for disposal.

Then, negative air pressure is established in the work area. That way, any air leaks will be from the outside into the contaminated area, rather than the other way around. Air is drawn in from the outside and exhausted through high-efficiency particulate air filters (HEPA) to remove asbestos fibers.

Workers dressed in hooded coveralls—called moon suits—and wearing respirators then remove the material. A number of techniques, such as scraping, are used and the material must always be kept wet to keep down dust levels. The waste, still wet, is double bagged and placed in containers to be taken to a landfill each day. No material is allowed to accumulate. Both the transporter that carries the sealed waste and the landfill that receives the asbestos must be certified. EPA requires that the asbestos be buried under at least 6 inches of dirt within the day. Finally, the area is carefully

real risks. Substitutes must be adequately tested, for example. "I'm concerned that if some material is not called asbestos, it is automatically exonerated from biological wrongdoing," says Langer.

Nicholson points out that asbestos in most products being manufactured today—cement pipe, for example—is tightly bound and not likely to become airborne easily. "The current hazard is from asbestos already in place—about a million tons of friable asbestos in insulation and pipe lagging that's going to have to be removed someday. That's a much greater problem than continued use of asbestos."

Asbestos abatement

A recent EPA report estimates that 15 million children attend schools where friable asbestos is present. An EPA survey of buildings other than schools estimates that 700,000 commercial, residential apartment, and federal buildings contain friable asbestos. The only current federal regulation that requires asbestos be removed from buildings is an EPA rule saying asbestos materials must be taken out of a building before it is demolished.

Two factors, however, are encouraging a growing

trend to rip asbestos materials out of buildings wherever these materials are found. One is EPA's asbestos-in-schools program, which requires school districts to inspect their buildings for crumbling asbestos. The second is building owners' fears that occupants may sue over future asbestos-related disease. Asbestos abatement—which includes both removal and sealing off asbestos in various ways—has become big business.

The asbestos-in-schools program has been lambasted from all sides for publicizing the presence of asbestos in schools but not giving school authorities enough help—either technical or financial—to deal with the problem rationally.

EPA publishes a booklet called "Guidance for Controlling Friable Asbestos-Containing Materials in Buildings" to help school authorities decide what to do when they find asbestos. It does not specify, however, that asbestos must be removed. Local officials must judge if that is necessary. Other options are to leave the asbestos-containing material alone, enclose it, or encapsulate it with a sealant that binds the fibers tightly. Many authorities in asbestos control agree that the problem is too complex to formulate general regulations that would fit every building situation.



Abatement worker scrapes asbestos-containing insulation from ceiling

cleaned by wet wiping and vacuuming with a HEPA-equipped vacuum.

"The moon suits are uncomfortable. They are hot and sweaty and it can be tough to work in a respirator," says Schopfel. "But in our company, productivity is pretty high. There's nothing else to do but work. It's hard to talk when you're wearing a respirator and you can't eat or drink. Any employee who takes off his respirator during work is fired."

Air samples are taken regularly throughout the entire operation to monitor fiber levels and check for leaks outside the work area. Also, contractors usually

are required to get the fiber levels—which are raised unavoidably during the removal work—down to a specified level before they can be released from the job, a procedure known as clearance monitoring.

"Clearance monitoring is a release mechanism saying the contractor has achieved certain levels under the best available technology," says Ian M. Stewart, vice president of McCrone Environmental Services. "It can't say you have a safe building. No one has told us what a safe level is."

Many contracts specify a final fiber level of 0.01 fiber per cc or less, as de-

termined by phase-contrast optical microscopy. However, that technique can pick up only large fibers and can't distinguish asbestos from other fibers.

EPA has been trying to draw up recommendations for final fiber levels and the best way to determine them, says Michael E. Beard, a chemist with the agency's R&D lab in Research Triangle Park, N.C. The agency is evaluating the three techniques—phase-contrast microscopy, scanning electron microscopy, and transmission electron microscopy (TEM)—that currently are used in determining postabatement asbestos air levels. The goal is to find an effective technique that's practical to use.

For instance, some researchers think that the indoor asbestos air levels after abatement work ought to be as low as those outdoors. However, to measure such very low levels would require electron microscopy—and probably the very expensive and not widely available TEM technique. "If all jobs are required to use TEM," says Stewart, "the turn-around time for samples will go to months rather than days. What do you do, leave the plastic tents up and buildings empty while you wait?"

So, as seems the case with everything else concerning asbestos control, EPA is faced with some difficult judgment calls on asbestos air monitoring.

"You have to decide on a case-by-case basis whether to remove asbestos," Selikoff says. "Asbestos does not constitute a hazard unless it is inhaled. Unless it can become airborne, there's no urgency in removing it. If it can be sealed off or is inaccessible and in good condition, it doesn't need to come out unless it will be disturbed by repairs or renovation. This can be planned for."

However, local school boards often lack the expertise and are too short of funds to hire experts to help them make the right decisions. "EPA is going in the right direction, but [it doesn't] have enough qualified people to supply guidance," Nicholson says. "Right now, some school administrators are so frightened that they panic when they see a crack in the ceiling. Others have the stuff falling all over and are not doing anything."

Says Susan Mazzochi, cofounder of Parents Against Asbestos Hazards in Schools, based in Maplewood, N.J.: "We discovered asbestos in our children's school and were shocked that the school board wasn't acting. The school board didn't want to do anything because it would cost money. In absence of any law that states how the problem should be addressed, it becomes a power struggle between the parents and the school board."

Another group that thinks EPA should take a more active role in asbestos abatement policy is the Service Employees International Union (SEIU), which represents about 100,000 school workers. Maintenance workers such as SEIU members are often the individuals expected to remove or clean up damaged asbestos materials in school buildings, sometimes with inadequate training and protective gear.

SEIU petitioned EPA in late 1983 to require corrective action when hazardous asbestos is found in schools and to issue regulations to protect school workers, who are not covered under OSHA. When EPA refused to act on all of the union's requests, SEIU filed a lawsuit against the agency in September 1984.

EPA is in an awkward position because no one can say exactly what levels of asbestos are hazardous. In certain situations where damaged asbestos is flaking into work areas and circulating through air-conditioning systems, the decision to remove it is straightforward. But most cases are not that simple.

"The appropriate action should be determined by a complete building survey by a qualified individual," says William H. Spain of the environmental health and safety division of Georgia Institute of Technology. Spain

Special Report

NRC's estimated cancer risk has wide margin of uncertainty

Exposure group	Individual lifetime risk of developing cancer, per million ^a	
	Exposure at 0.0004 fiber/cc ^b	Exposure at 0.002 fiber/cc ^c
LUNG CANCER		
Male smoker	64 (0 to 290) ^d	320 (0 to 1500)
Female smoker	23 (0 to 110)	120 (0 to 530)
Male nonsmoker	6 (0 to 22)	29 (0 to 130)
Female nonsmoker	3 (0 to 13)	15 (0 to 66)
MESOTHELIOMA		
All	9 (0 to 350)	46 (0 to 1700)

Note: For example, the risk of developing lung cancer for a male smoker who is exposed throughout his lifetime to an asbestos concentration of 0.0004 fiber per cc probably is about 64 in 1 million, but may range from 0 to 290 in 1 million. ^a Lifetime assumed to be 73 years. Exposure occurs continuously from birth. ^b Approximately equivalent to asbestos concentration in urban outside air. ^c Approximately equivalent to asbestos concentration in U.S. schoolrooms with asbestos surfaces. ^d Range of estimates. Source: "Asbestos: Nonoccupational Health Risks," National Academy Press, 1984

and his colleagues in Georgia Tech's asbestos programs group offer courses for building owners, architects, contractors, and others on managing asbestos. Their course on supervising asbestos abatement contracts is so popular that they have offered it 15 times since its inception in May 1982.

Georgia Tech is the site of one of three new asbestos information centers, funded by EPA and opening this year to answer questions about controlling asbestos. "Bill Ewing [William M. Ewing, also at Georgia Tech] and I could spend 10 hours a day on the phone talking about asbestos," Spain says.

Spain does not think air levels of asbestos should be the criteria for determining the need for abatement. "Air samples are like a photograph, they reflect only the

circumstances at that particular time. Air levels that are low during normal activities might be higher during certain maintenance procedures that might disturb the asbestos, like changing light fixtures or running telephone lines," he says.

Given the popular notion that even the smallest bit of asbestos is deadly, many school systems and building owners are rushing to take it out. Unfortunately, this can sometimes turn a potential risk into an actual one.

"If building surveys and abatement work are not done correctly, the hazard could be made many, many times worse than it was initially," Spain says. "A substantial, or at least a noticeable, portion of abatement projects are being done in such a way as to put people at risk." The Canadian report also points out that removal projects can increase the risks of asbestos-related disease.

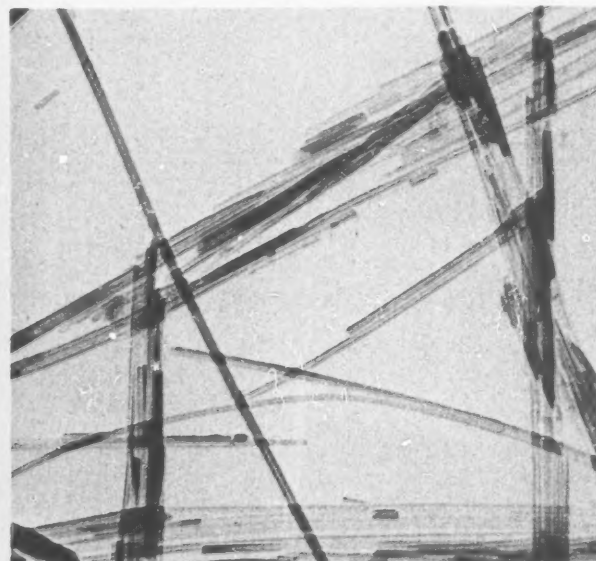
The danger lies in not containing the asbestos as it is removed. Both abatement workers and bystanders then are exposed to loose fibers as the removal work is going on. In addition, asbestos fibers, which take a long time to settle out of the air, can become caught up in the air-circulation system of the building and subject the occupants to sizable doses once they return to a supposedly clean building.

Indeed, tenants of the 17th floor of the Medical Towers building in Houston have filed a \$110 million suit against the building manager and a contractor who remodeled the 18th floor last summer. The plaintiffs charge they were exposed to asbestos dust and now have increased risk of getting cancer.

The consequences of acting too hastily to remove asbestos are also apparent in New Jersey, where about 300 schools were scheduled to have asbestos taken out last summer. As the opening of the fall school term approached, it became clear that many of the jobs had been done sloppily and with inadequate monitoring. Most of the schools opened on time anyway.



McCrone Environmental Services photo



Bureau of Mines photo

Magnified 148X under polarized light, chrysotile fiber bundles appear blue and purple. The characteristic hollow-tube structure of individual chrysotile fibrils is visible in the transmission electron microphotograph (35,000X)

Property liability lawsuits multiplying rapidly

When Manville Corp. (formerly Johns-Manville) filed a bankruptcy petition in August 1982, it was seeking protection from millions of dollars in claims by more than 18,000 people suffering from asbestos-related diseases. Now, however, other asbestos manufacturers are being deluged with lawsuits from building owners. These fast-multiplying property damage suits may turn out to be even more expensive than the health-related ones.

For example, last September the state of Maryland filed suit against 47 asbestos producers for the cost of cleaning asbestos out of 3000 buildings owned by the state. "The suit asks for \$500 million in compensatory damages," says Evelyn O. Cannon, assistant attorney general. "We also asked the court to require the defendants to come

into the buildings, identify the asbestos, remove it, and replace it with substitutes," she adds. The first hearing in the state's suit is scheduled for later this month.

If the size of Maryland's suit turns out to be typical, a crude extrapolation yields many billions of dollars at stake in suits from state governments alone. Businesses, local governments, and private homeowners also are potential plaintiffs in such suits. So is the federal government, but the Department of Justice indicates it probably won't sue. However, a Justice Department report encourages school systems to try to recover the costs of their abatement projects from asbestos manufacturers.

A decision last fall by a federal judge in Philadelphia cleared the way for a

class action suit by schools against asbestos producers. Judge James M. Kelly ruled that a combined suit would let thousands of small school districts sue to recover the money they've spent to remove asbestos without being burdened by prohibitively high legal costs. Districts may sue on their own for compensation, his ruling said, but all punitive damages will have to be part of the class action.

Because Manville is in bankruptcy, it can't be sued directly as the other asbestos producers can. Chairmen against Manville instead must petition the bankruptcy court. When a deadline expired last Jan. 31, more than 3500 property damage claims had been filed. For other companies not under the protection of Chapter 11, the suits will continue to snowball.

"Most of the contractors who have been hired by the school boards to perform asbestos removal work have little experience in this specialized and sensitive field," states a report issued last August by New Jersey's Department of the Public Advocate. "Because many good contractors are overextended, there is a lack of qualified asbestos removal workers."

As a result, inspectors found workers tracking asbestos out of sealed areas, flushing asbestos down toilets, not wearing protective respirators or clothing, and hauling asbestos away in private cars, as well as numerous other abuses of good work practices.

To counter such abuses, there should be some way to demonstrate who's qualified to do asbestos abatement work. Some states already have contractor certification requirements. An incentive for the rest of the states to introduce certification procedures is built into the Asbestos School Hazard Abatement Act of 1984. That law, which gave EPA \$50 million in fiscal 1985 to assist states and local school districts with asbestos control, requires states to certify contractors.

The asbestos programs group at Georgia Tech is developing a model one-week training program for asbestos abatement supervision under an EPA contract. Another organization, the National Asbestos Council (NAC)—composed of contractors, building owners, architects, analysts, and other professionals concerned about proper asbestos abatement—is developing training materials for small contractors and maintenance personnel who have to deal with asbestos.

A different problem is starting to put even well-qualified contractors out of work, however. "We're starting to hear of contractors that can no longer get liability insurance," says McCrone Environmental Services' Stewart, who is past president of NAC.

"In the past two weeks I've heard from at least 15 contractors who are losing their insurance," echoes Brent W. Schopf, a contractor who is a charter member of the National Association of Asbestos Abatement Contractors. Insurance companies, burned by massive personal injury and property damage claims against asbestos manufacturers, are specifically excluding asbestos abatement work as contractors' general liability policies come up for renewal.

"If something isn't done, all of the abatement work is going to grind to a halt," says Stewart M. Huey, executive director of NAC. He suggests that state insurance commissioners may have to create an assigned risk pool, as is done for workmen's compensation. Or the federal government could start a reinsurance program, as is the case with flood and nuclear power plant insurance.

"It's a nasty problem and a lot of people are working on it," says Schopf. "It's going to be an interesting summer."

All of the problems with asbestos abatement are exacerbated by panicky, oversimplified responses to a complex issue. "I think we ought to control asbestos," says Langer. "We should not tear it out indiscriminately and then tax society \$20 billion. In some cases it may not have to be removed. Where it does, we don't have the trained people to remove it properly and we may increase risks by taking it out. We live in a chemical society. Let's learn to control and live with these materials." □

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■ C&EN senior editor wins George Polk Award for special interest reporting. **Page 7**

■ Researchers determine structure of supersweet protein. **Page 7**

■ Union Carbide no longer will ship methyl isocyanate in that form when it reopens Institute Plant. **Page 8**

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Wall Street analysts see the Chesebrough-Stauffer merger as protective measure by two firms vulnerable to takeover. **Page 10**

Worldwide production of man-made fibers reached an all-time high last year at 33.6 billion lb but U.S. share declined. **Page 11**

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Books

"Modern Meat" by Orville Schell explores the use of drugs in farm animals and the drugs' potential danger to humans. **Page 80**

Cover: Photo by C&EN's Stephen C. Stinson

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Instrumentation '85

Automation to boost productivity in the analytical lab was much in evidence at the Pittsburgh Conference, held in New Orleans' new convention center. **Page 29**

chemicals division and especially of Stauffer's understanding of its markets in the agricultural chemicals business and of the economics of the farm markets into which the company has been selling.

Part of the problem with the company's pesticide unit—whose sales in the 1984 fiscal year ended last Sept. 30 were 17% below 1980 sales—was outside Stauffer's control and had to do with weather and the government's payment-in-kind crop set-aside program. But analysts say that Stauffer, which thought it could fix much of the company through the agricultural chemicals unit, missed an important concept of farm economics—namely, how the farmers would cultivate the soil. When the market was moving toward no-till and minimum-till planting, Stauffer was selling preplant incorporated herbicides, which increase, rather than decrease, the number of trips the farmer has to make through his field. In spite of increased use of herbicides in reduced tillage practices, most of the increase is in post-emergent products, where Stauffer is weak. "The company essentially was trying to sell last year's product into this year's market," says one analyst.

The one product that the company has as a hope in the new agricultural environment is Touchdown, a glyphosate herbicide designed to compete with Monsanto's Roundup. However, Stauffer is involved in patent litigation with Monsanto in the U.S. and abroad, and the outcome of this is likely at least two years away. Even if Touchdown makes it through the court battles, according to one analyst, Stauffer will not be able to get the share of market that it would like to have, and it probably cannot expand the market any more. "So Touchdown could be a nice product," he says, "but it's not going to be a \$250 million per-year product."

Analysts say that Morley began to take steps to repair the company, except for agricultural chemicals, about three years ago. One, for instance, gives him credit for getting rid of some problem businesses. But, he says, because of two years of indecision prior to that, the time-

table for when Stauffer would be a great company was pushed back. And it went off in a lot of different directions—biotechnology, oil and gas, and diagnostics—because those areas sounded good. Some of the areas that Stauffer got into look interesting, but there are five- or 10-year payoffs for them.

Just what Stauffer is going to do for Chesebrough is open to question, also. One analyst says that Stauffer had been looked at by chemical companies that decided that the problems were just too great to justify the price tag. But, he says, a chemical company could have cut costs significantly because of duplication of services. Chesebrough, according to him, comes in with no expertise in chemicals and has no management to bring to it and no way to cut costs because there is no duplication. "There is zero synergy," he says. "It is just the wrong company to buy Stauffer at this time."

Others are not so uncharitable, however. They point out that although there are big problems in

the agricultural chemicals and fabricated products units, there are highly profitable parts of the chemicals business, such as sulfuric acid reprocessing, and of the specialties unit, such as silicones. Also, according to one analyst, there is great potential in phosgene-based specialties. He adds that this could be scary for Chesebrough, however, in the aftermath of Union Carbide's Bhopal accident, which involved methyl isocyanate, a phosgene-related chemical.

Finally, one analyst says that ultimately the acquisition could be cheap for Chesebrough. If the company could sell off the agricultural chemicals business (though Ward has said he will not sell off any part), it probably could get about \$500 million for it. Add to this some internal cash realized through accounting changes and other sources of which Chesebrough will be the beneficiary, and the cost comes out to hundreds of millions of dollars rather than the \$1.25 billion that Chesebrough will be paying.

William Storck, New York

Global man-made fibers output hits record high

Production of man-made fibers throughout the world last year was the highest ever. It amounted to 33.6 billion lb, more than 3% ahead of 1983. This fiber grouping includes not only those fibers made entirely by chemical syntheses but those, such as rayon, that involve considerable processing of natural cellulose into fibers.

This all-time record was achieved through synthetic fibers growth. According to the latest annual survey of the global industry compiled by analysts at Enka, the fibers-producing arm of Akzo of the Netherlands, synthetics accounted for almost 79% of world output, accounting for 26.5 billion lb. Cellulosics, output of which has been declining for some years, contributed the remaining 21% of global production, or 7.2 billion lb.

Growth of synthetics at the expense of cellulosics is more evident when last year's figures are compared with those of 1975. In that year, with total output amounting

to 23.5 billion lb, synthetics accounted for 70% (16.4 billion lb) and cellulosics 30% (7.1 billion lb). Since 1975, synthetic fibers production has increased at an average annual rate of 5.5%, whereas cellulosics output has remained essentially static.

On a regional basis, the U.S. continues to lead in synthetic fibers output. Last year, it held a 26% share of the world total (almost 7 billion lb), followed by Western Europe with 20% (5.4 billion lb), and Japan with almost 12% (3.1 billion lb). The rest of the world lumped together accounted for nearly 42% of the total, or about 11 billion lb.

There is little room for complacency as far as the U.S. is concerned, however, since its share of overall output continues to decline, as it also has been doing for Western Europe and Japan. In 1975, the U.S. produced 34% of the world synthetic fibers total (5.5 billion lb), Western Europe 25% (4.1 billion lb), and Japan 14% (2.3 billion lb). All other countries combined produced the

Global man-made fibers production in 1984 reached 33.6 billion lb . . .

	1984	1983	1982	1981	1980
U.S.	4.52 (13.5%)	4.50 (13.4%)	4.34 (12.9%)	4.40 (13.0%)	4.52 (13.7%)
Western Europe	4.42 (13.2%)	4.37 (13.0%)	4.23 (12.6%)	4.41 (13.0%)	4.30 (12.8%)
Japan	4.28 (12.7%)	4.21 (12.5%)	4.07 (12.1%)	4.12 (12.3%)	4.08 (12.1%)
Other	10.78 (31.8%)	10.69 (31.7%)	10.37 (30.7%)	10.35 (30.6%)	10.37 (30.7%)
Total	33.64 (100%)	33.59 (100%)	33.38 (100%)	33.34 (100%)	33.48 (100%)

. . . owing to an increase in synthetics production

	1984	1983	1982	1981	1980
U.S.	2.82 (8.4%)	2.83 (8.4%)	2.85 (8.5%)	2.84 (8.5%)	2.87 (8.6%)
Western Europe	2.41 (7.2%)	2.39 (7.1%)	2.38 (7.1%)	2.42 (7.2%)	2.39 (7.1%)
Japan	2.06 (6.1%)	2.04 (6.1%)	2.01 (6.0%)	2.02 (6.1%)	2.01 (6.0%)
Other	11.52 (34.3%)	11.25 (33.4%)	11.22 (33.3%)	11.19 (33.2%)	11.21 (33.3%)
Total	33.67 (100%)	33.51 (100%)	33.46 (100%)	33.55 (100%)	33.48 (100%)

balance of almost 28% of the world total, or 4.5 billion lb.

Viewed in terms of average annual growth, synthetic fibers output in the U.S. has grown 2.6% annually since 1975. In both Western Europe and Japan it has increased 3.2% a year. But in the rest of the world, annual growth has exceeded 10%. Indeed, synthetics output in the U.S. last year was unchanged from 1983. For man-made fibers as a whole, growth in the U.S. was a mere 0.2% to a little more than 8 billion lb.

Worldwide output in 1984 of the three broad classes of synthetic fibers—acrylics, polyamides, and polyesters—advanced an average of about 4% from its 1983 level. Acrylics production rose 3.9% to 5.02 billion lb, polyamides 3.1% to 7.3 billion lb, and polyesters 4.7% to 12.8 billion lb. Production of fibers from polypropylene, polyvinyl chloride, elastomerics, and the like, grouped together as "others," advanced 7.1% to 1.4 billion lb.

The relative proportion of the fiber types made, on the other hand, remained the same as in 1983—19% acrylics, 28% polyamides, 48% polyesters, and 5% others. And this ratio was essentially unchanged from the 1980 profile, apart from the other fibers, which collectively gained 1% of the total at the expense of a corresponding drop in polyamides.

More significant is the comparison with the 1975 production split.

In that year, acrylics still accounted for 19% (3.1 billion lb), whereas polyamides amounted to 34% (5.5 billion lb), and polyesters 45% (7.4 billion lb). Other fibers accounted for only about 3% of output (440 million lb).

Between 1975 and 1984, output of the "other" fibers spurted at more than a 13% annual growth rate, for an absolute gain of 209%. That compares to an average annual growth rate for polyesters of 6.3% (up 73% for the decade), acrylics 5.7% (up 65%), and polyamides 3.2% (up 33%). During that period, synthetic fibers production's 5.5% annual growth rate resulted in a decade gain of 61% to 26.5 billion lb.

Polyester retains its pride of place among synthetic fibers. It also has been undergoing the fastest rate of growth. Last year's 12.8 billion lb of output accounted for more than half the global production of the three major fiber categories, with the balance split between polyamides at 29% and acrylics at 20%. The 1975 profile stood at 46% polyester (7.4 billion lb), 35% polyamides (5.5 billion lb), and 19% acrylics (3.1 billion lb). As for average annual growth rates during the nine-year span, polyester led with 6.2%, followed by acrylics' 5.7%, and polyamides' 3.2%.

Regional results for polyester last year varied widely. In the U.S., polyester fiber production declined 3% from 1983 to 3.5 billion lb. In Japan

it gained 2% to 1.4 billion lb. And in Western Europe it rose 8% to 1.9 billion and in other regions of the world it gained 7% to 6 billion lb.

The U.S. fared a mite better in acrylics and polyamides, with a 1% gain in each to 650 million and 2.42 billion lb, respectively. Acrylics production increased 3% in both Western Europe (to 1.7 billion lb) and Japan (to 800 million lb), and in the rest of the world it rose 4% to 1.9 billion lb. Polyamides production in Western Europe last year increased 2% to 1.3 billion lb; in Japan it rose 4% to 660 million lb, and in the other world regions it surged 9% to 2.9 billion lb.

For 1985, Enka market analysts foresee a number of conflicting trends that will have positive and negative impacts on the fibers business. They believe, for instance, that the upswing in the world economy will continue. However, if growth in the U.S. levels off, "the increase in world trade probably will remain below that of the previous year."

As regards Western Europe, "a high sales volume for the man-made fibers industry is anticipated, at least for the first half of 1985." Exports will continue to be the mainstay of economic growth. On the other hand, much will depend on the movement of the U.S. dollar in relation to other major currencies. Last year, its strength helped spur sales of European goods in dollar trading areas. □

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FINAL PROGRAM
ACS spring meeting,
Miami Beach Page 37

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News of the Week

■ NBS physicists have used laser light to slow down neutral atoms, allowing them to be better observed. **Page 4**

■ Antinausea drug Bendectin has been cleared of charge that it causes birth defects. **Page 5**

■ Panel charged with reviewing U.S. chemical warfare capability and policy begins work. **Page 5**

■ Department of Energy's plan for nuclear waste disposal draws fire from Office of Technology Assessment, which offers its own plan. **Page 6**

■ EPA is reconsidering its decision to refer proposed asbestos ban to other agencies. **Page 6**

Cover: Oriented, flexible film of poly[bis(trifluoroethoxy)phosphazene], or $[\text{N}(\text{P}(\text{OCH}_2\text{CF}_3)_2)]_n$

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Business

Possible increased trade with Soviets looked at by U.S. chemical industry with little enthusiasm. **Page 8**

International Business

Arco Chemical Europe, feeling expansive, reveals plans to build plants in France and the Netherlands. **Page 10**

Government

Department of Defense argues for binary chemical arms, insisting they are needed for credible deterrent. **Page 13**

Agricultural research establishment gets more advice; report from NRC spotlights areas for change. **Page 14**

Debate surrounds budget cuts for research and development on fossil energy sources. **Page 16**

Science

Chemists modify FTMS and show high-resolution spectra, efficiencies, and separation speeds. **Page 18**

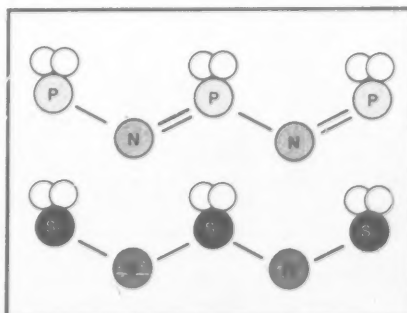
International team of physical chemists comes up with equation to predict solubility of any compound in any solvent. **Page 20**

Final Program

Complete technical program given for 189th ACS National Meeting to be held in Miami Beach April 28 through May 3. **Page 37**

ACS News

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Special Report

New high-molecular-weight polymers that contain inorganic elements in their backbones are eyed for use as high-tech materials, electrical conductors, and biomedical. **Page 22**

Chemical Industry Cool to Prospects For Increased Trade with Soviets

Administration's attempts to improve trade relations with U.S.S.R. probably won't increase currently small volume of chemical trade

The Reagan Administration is sending out signals that it wants to improve trade relations with the Soviet Union. But the U.S. chemical industry so far is remaining cool to these prospects.

Earlier this year, Lionel H. Olmer, the Commerce Department's undersecretary for international trade, met with his Soviet counterparts in Moscow. He is the highest-ranking U.S. trade official to visit Moscow since the Carter Administration days.

The Reagan Administration also has proposed a meeting of the U.S.-Soviet Commercial Commission, a Cabinet-level group that monitors

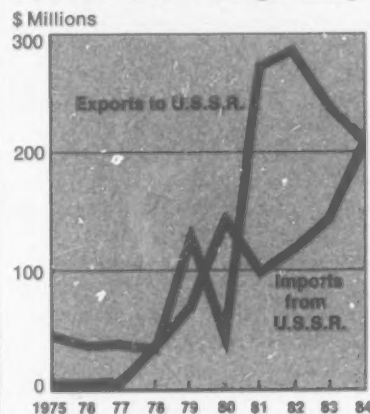
U.S.-Soviet trade. The commission hasn't met in six years. U.S. officials are hoping for a late spring meeting in the U.S.S.R., but so far the Soviets haven't responded to the U.S. proposal.

These first steps toward improved trade relations between the two countries certainly offer no guarantees. But they are welcome news nonetheless to many U.S. business interests, especially agriculture, that hope to benefit from increased sales to the Soviets.

The chemical industry, however, isn't particularly enthusiastic or optimistic. According to one industry trade expert, the prospect of improved trade relations between the U.S. and the U.S.S.R. "is no big deal" for U.S. chemical companies. He doesn't anticipate any "big push" on their part to increase chemical exports to the Soviet Union.

There may be a few isolated exceptions to that assessment. A U.S. government trade official says that he has detected some interest among

U.S. chemical trade with U.S.S.R. small but growing



Source: U.S. Bureau of the Census

exporters of plastics and agricultural chemicals to gain a foothold in the Soviet market. But for the most part, trade with the Soviets will remain well down the list of the chemical industry's international problems.

Last year, chemical exports to the U.S.S.R. accounted for less than 1% of total chemical exports. Soviet chemicals amounted to only 1.5% of the U.S. chemical import total. So even if chemical trade in both directions were to increase substantially on a percentage basis, it still would represent only a small portion of overall U.S. chemical trade.

Chemical exports to the Soviet Union in 1984 amounted to \$208 million. Although that figure is much higher than the \$30 million to \$40 million level that prevailed in the late 1970s, it marks the second successive year in which chemical exports to the Soviets declined. In 1982, they hit \$288 million.

Another significant aspect of U.S. chemical exports to the U.S.S.R., in addition to the small volume, is their composition. Last year, almost 90%,

U.S.-U.S.S.R. chemical trade was in balance last year

\$ Millions	Exports to U.S.S.R.		Imports from U.S.S.R.	
	1983	1984	1983	1984
Organic chemicals	\$ 0.4	\$ 3.6	\$ 2.0	\$ 12.0
Inorganic chemicals	223.9	189.0	88.0	141.7
Radioactive materials	0	0.3	9.9	0.2
Dyeing, coloring & tanning materials	neg	0	0	0
Pigments, paints & varnishes	3.5	2.9	0	0
Medicinals & pharmaceuticals	1.0	1.3	neg	neg
Flavor, perfumes, cosmetics & toiletries	neg	neg	neg	neg
Cleaning & polishing materials	neg	neg	0	0
Fertilizer, manufactured	2.9	0	43.0	53.7
Explosives & pyrotechnics	0	0	0	0
Plastics & resins	1.7	3.1	neg	0
Pesticides & disinfectants	0.7	1.7	0	0
Miscellaneous	5.3	3.2	0.8	0.2
TOTALS	\$239.4	\$206.1	\$143.8	\$207.8

neg = negligible. Source: U.S. Bureau of the Census

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Business

or \$186 million, was accounted for by fertilizer-grade phosphoric acid, reflecting the now-famous barter deal that Occidental Petroleum chairman Armand Hammer negotiated with the Soviets. The slim \$22 million remainder was split among small volumes of paints and pigments, medicinals, some plastics, and a host of miscellaneous chemicals.

Unlike chemical exports, chemical imports from the U.S.S.R. have been increasing over the past few years. They have grown from \$94 million in 1981 to \$208 million last year. By comparison, they were only a miserly \$6 million in the mid-1970s.

More important, that value of chemical imports from the Soviets means that U.S.-Soviet chemical trade was in balance last year. With very few exceptions, the U.S. has enjoyed a chemical trade surplus with the U.S.S.R. for years.

Despite this achievement, chemical trade between the U.S. and the U.S.S.R. is not much more significant to the Soviets than it is to the U.S. United Nations statistics, which detail complete chemical trade flows throughout the world, tell the story. In 1982, the latest year for which complete statistics are available, the U.S.S.R. exported \$2.35 billion worth of chemicals. The \$118 million that it shipped to the U.S. that year represented only 5% of the total.

The U.S.S.R. does rely on western nations for much of its chemical export business, but the primary target is Western Europe. In 1982, for instance, 35% (\$823 million) of its chemical exports went to western, developed nations. Western Europe took 80% of that amount.

The Soviet Union imported twice as much chemicals (\$4.7 billion) as it exported in 1982, but the geographic distribution is similar. Western and Eastern European countries are the dominant suppliers, with the East holding a slight edge. The U.S. accounted for only 6% of Soviet chemical imports.

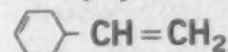
Thus, U.S.-U.S.S.R. chemical trade represents only a small slice of the pie for both countries. And even if a thaw does materialize in U.S.-Soviet trade relations, its impact on the overall chemical trade picture is not likely to be significant.

Earl Anderson, New York

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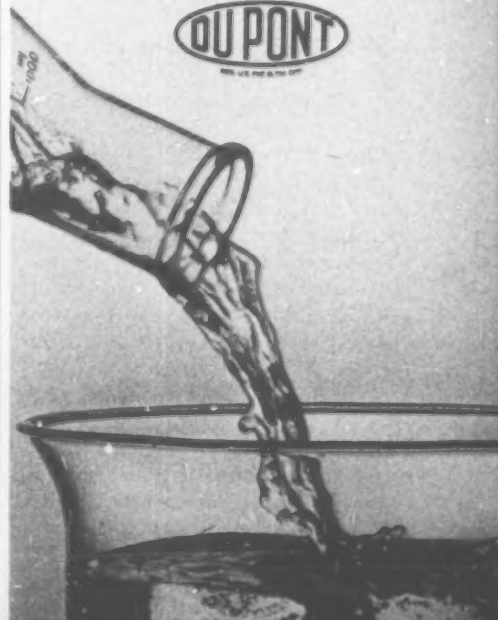
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First commercial methanol-
to-gasoline plant nears operation
in New Zealand Page 39

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Research**
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■ Union Carbide's long-awaited report on Bhopal gas leak offers hypothesis of how reaction may have occurred. **Page 4**

■ Interior Department orders closing of California's Kesterson Reservoir amid farmer protests; cleanup to follow. **Page 5**

■ Silvex and 2,4,5-T pesticides, once commonly used as weed killers, have their final uses canceled. **Page 6**

■ White House council urges government to increase support for environmental research. **Page 6**

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Scientific panel reviews evidence for disease caused by exposure to environmental chemicals, finds little correlation. **Page 29**

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U.S. biotechnology firm, a midget among giants, is testing five new products with commercial potential. **Page 32**

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Institute for Chemical Education expanding summer programs for chemistry teachers and middle school students. **Page 38**

Technology

Mobil's methanol-to-gas process will debut commercially in New Zealand plant built by modular construction. **Page 39**

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"A Killing Rain: The Global Threat of Acid Precipitation" by Thomas Pawlick examines problems attributed to acid rain. **Page 42**

ACS News

Six petitions are up for council action—two concerning emeritus and retired status of members—at Miami Beach meeting. **Page 44**



News Focus

Dow Chemical's R&D has been redirected toward entrepreneurialism, new product development to achieve goal of 50% of sales in specialties by 1993. **Page 9**

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LETTERS

Pacific Basin economic growth

SIR: The account of Messrs. Sekhar and Swaminathan's activities (C&EN, Jan. 14, page 48) concerning the promotion of economic growth in the Pacific Basin is good news. Specifically, the development of integrated agroindustrial complexes—the total utilization of rice, rubber trees, oil-producing palms, and other crops (including the nonmentioned sugar cane); and the nontraditional uses of traditional agricultural commodities—is worthy of maximum attention throughout the world.

I also agree with the need to interest the mass media in value-added agroindustrial transformation so that responsible leaders and policy makers of the developing nations may give these efforts the top priority they deserve.

Readers concerned with the improvement of life for the majority of the world's population may be interested to learn that the Organization of American States has sponsored a 10-day, similarly oriented workshop, "Industrial Utilization of Renewable Resources," in Jamaica, Jan. 2–12, for participants from the Caribbean Basin countries. This workshop is to be repeated next May in Montevideo, Uruguay. Also, the forthcoming First Pan American Chemical Congress scheduled for Oct. 13–19, in San Juan, P.R., will include a relevant symposium—"Material Transformations: the Key to Economic Growth of the Americas."

H. Harry Szmant, *Adjunct Professor*
University of Miami, Coral Gables, Fla.

Rebuttal to Hartford

SIR: In his letter to C&EN (Feb. 11, page 2), Prof. Hartford suggests (in his third and fourth points) that it is possible for people to be completely objective about "secular knowledge" so that it can be presented without "distortion." He uses creationism as an example. Evolution is a philosophy just as creationism is. It is impossible for an adherent of either philosophy (or of any other philosophy) to present scientific evidence without interpreting it in light of the biases of his/her philosophy.

Hartford says that the issue of abortion "is nothing to be mandated by Big Brother." By common consent, the members of our society have declared that theft is wrong. Accordingly, we have mandated and legislated that the perpetrators of this immoral act be punished. We do not make "judgment calls" and say that theft is justifiable in one instance but not in another. Many in our society believe that abortion is immoral. To those who believe this way, it is just as correct for our society to

mandate action against abortion as it is to mandate action against theft.

Hartford makes it clear that he espouses secular humanism. This is in itself a philosophy that, as Hartford says so well, asserts "that a true faith is dedicated to the ascent of man." Certainly he has the privilege of choosing his beliefs. It is ironic, however, that on the one hand he says that second graders should be able to decide about religion on their own, but on the other hand (in this third point) he suggests that "sectarian" philosophy and religion in educational institutions "distort" knowledge and that such institutions should be penalized by having state aid withdrawn from them. This is tantamount to declaring secular humanism as a state religion: If your school refuses to deliver "secular knowledge" in a way that contributes "to the ascent of man" (secular humanism), then your school will be penalized.

He states that "no man can speak for . . . the Infinite" and readily impugns what he refers to as "sectarianism." I suggest that this is nothing more than a sweeping condemnation of most of organized religion. It most certainly condemns those who adhere to Biblical teaching: Christ himself made many statements that are "sectarian" and that speak for the "Infinite."

In his concluding paragraph Hartford may be trying to be fairminded, but he has failed to do so. He chooses as an "essential for freedom" the independence of secular knowledge from the sectarian distortions imposed on it by some religious beliefs. I suggest that this in itself would ultimately deprive the individual of freely expressing his philosophy and religion the way he chooses to. Rather than being an essential for freedom, Hartford's proposal is the antithesis of freedom.

Brian S. Vogt, *Greenville, S.C.*

Corrections

• Dec. 24, 1984, page 20: Data presented in the table are misleading. They are for the maximum emission of pollutants from Union Carbide's Institute, W.Va., plant at given times. Constant average emission levels are much lower. Also, source of these data is the West Virginia Air Pollution Control Commission, not the U.S. Occupational Safety & Health Administration.

• March 18, page 106: The correct address for Barbara G. Wood, chairman of the Publications Committee, is Research Library Manager, Rohm & Haas Co., P.O. Box 718, Bristol, Pa. 19007

Major Changes Could Confront Basic Petrochemicals This Year

As new foreign producers' lower-cost output rises, U.S. industry faces changes in product lines, plant capacities, and operating methods

Bruce F. Greek, C&EN Houston

This could be the year in which long-forecast major changes begin to affect the basic U.S. petrochemical industry. Most industry sources expect only modest, if any, gains in production in 1985. But, after this year, small declines in output could begin as a result of loss of export markets for most petrochemical derivatives. And increased competition in U.S. markets will develop from imports of derivatives made in other countries with lower-cost feedstock and fuel costs.

This leveling-off of production growth of basic petrochemicals will lead to many changes in product

lines, plant capacities, and operating methods. Some of the changes could be more severe than the present situation warrants, say some industry sources. For example, the well-known shift by producers of commodity chemicals to specialties may be overdone, with the profitability of the shifts now in question in many cases. Another example is in current growth in grades and product specifications aimed at pro-

Some 2.5 billion lb of dehydrogenation capacity to make butadiene was shut down from 1974 to 1984, with as much as 80% apparently being scrapped. Much of this capacity was replaced by coproduct butadiene from the rapid expansion of steam cracker capacity during the second half of the 1970s.

A large amount of steam cracker capacity fits into the category of potential shutdown. And any shift toward the heavier feedstocks for steam crackers could increase the effective capacities of important coproducts such as propylene, butadiene, and the aromatics.

A secondary effect on petrochemical capacity could result from the perceived impact of petrochemical products from the new plants in the Middle East. The seriousness of this effect will become clearer in a year or so after most of the Middle Eastern units are operating.

For more on the outlook for basic petrochemicals, see the following pages.

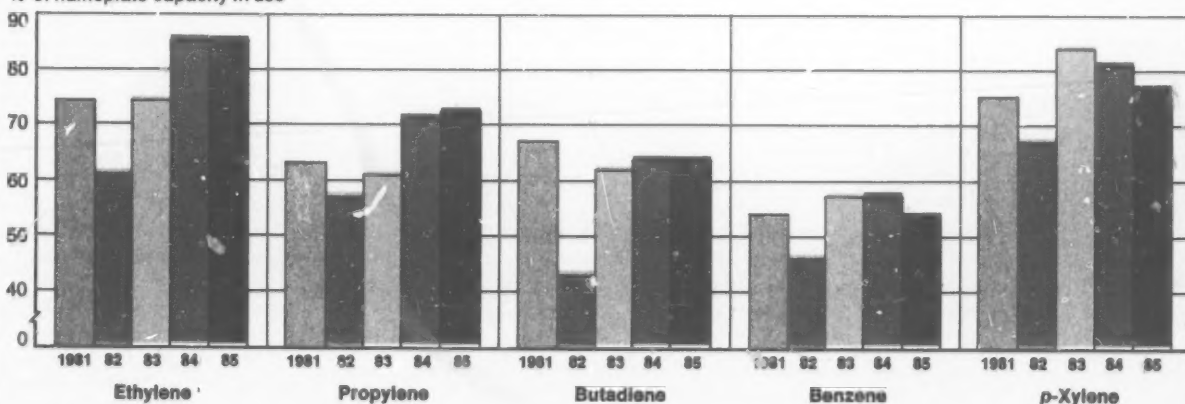
Key Chemicals

viding a product obtainable only from a single source. This may be a worthwhile marketing technique, but it does boost inventory costs.

Capacity to make basic petrochemicals certainly will decline for some time under price pressure as it affects profitability. For some products, the shutdown could be huge—as large as the already-completed shutdowns of butadiene capacity.

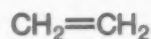
Plant-use rates will level off or drop this year

% of nameplate capacity in use



Sources: U.S. Trade Commission, C&EN estimates

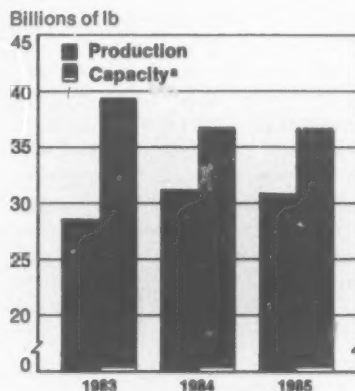
Key Chemicals



Ethylene

- **Production holding**
- **Capacity may rise**
- **Prices down**

PRODUCTION/CAPACITY



a First quarter; includes shutdown capacity not expected to restart.

MAJOR PRODUCERS

Arco Chemical, Dow Chemical, Exxon Chemical, Shell Chemical, Union Carbide

HOW MADE

Thermal (steam) and catalytic cracking of hydrocarbons ranging from ethane to heavy gas oil

MAJOR DERIVATIVES (U.S.)

Polymers 50%, ethylene oxide 20%, vinyl chloride 15%, styrene 5%

MAJOR END USES (U.S.)

Fabricated plastics 70%, antifreeze 10%, fibers 5%, solvents 5%

FOREIGN TRADE

Exports and imports negligible

PRICES

About 16 cents a lb for most merchant sales (about 30% of production)

U.S. ethylene production last year, at about 31.2 billion lb, may not be surpassed until late in the 1980s. That's about when domestic demand finally will have made up for losses in exports of ethylene derivatives being supplied instead by new foreign competitors.

Production of ethylene in 1985 likely will match last year's. That output level will depend on the current economic trends continuing into the summer, and it also takes into account increasing exports of ethylene derivatives by newcomer producers in the Middle East and elsewhere. It might be a different story, of course, if the U.S. economy improves and if exports of derivatives from other parts of the world decline just modestly, perhaps 10% on the average. In that case, 1985 production could surpass last year's by about 500 million lb. If, on the other hand, the U.S. economy falters in the second half of 1985, and if foreign producers of ethylene derivatives take away a larger part of U.S. exports, then ethylene production could decline—as much as 1 billion lb, or about 3%, by some estimates, to 30 billion lb.

Currently, more than 36 billion lb of nameplate capacity is available for ethylene production. Not all of this capacity is operating, because of low profitability or no profitability to producers at today's prices. It's widely estimated about 2 billion lb of capacity currently is idle but could be operating. These figures mean that operations at an annualized rate of about 31 billion lb are at almost 90% of the on-stream capacity and at 85% of available nameplate capacity.

Some small additional capacity likely will be returned to operable nameplate capacity within a year. For example, by early 1986, an ethylene unit, now owned by Occidental Chemical but built by Cities Service near Lake Charles, La., will be modernized and restarted, adding about 500 million lb to the total U.S. capacity. That will be

the only addition to capacity other than debottlenecking programs, which are expected to add minor amounts to the capacity total during 1985.

However, some of the very old capacity, built more than 15 years ago, could be taken permanently out of potential operability during the next year. This old capacity accounts for between 10 and 15% of the nameplate total. If a fifth of it is scrapped in 1985, the loss would be about equal to expected additions. The shutdown and scrapping of all the old capacity will come along in bits and pieces, probably over five years.

Scrapping of old capacity depends on many factors, most important of which is profitability. Even though depreciated, such capacity is inefficient to operate. To raise the efficiency of some units might cost as much as to rebuild completely, and could possibly cost more than would additions to a more modern unit. Moreover, an old unit might require more costly feedstocks than are available, as a result of changes in demand for various hydrocarbons from petroleum and natural gas.

A decision to buy ethylene rather than to make it also could cut into old capacity. And a large decline in exports of ethylene derivatives also could speed decisions to discontinue ethylene operations at marginal production units. Although a producer might now have little export business in derivatives, competition still could increase because other producers need to find a place for derivatives that they can't export profitably.

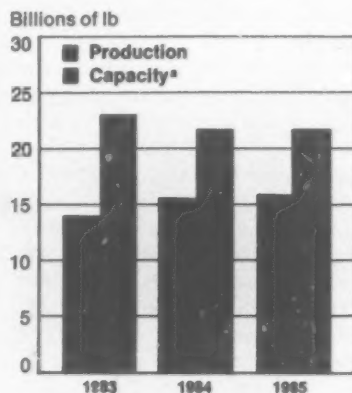
Even with some probable loss in exports of ethylene derivatives, with strong competition for sales, and with some shifting around in operating capacity, the overall use pattern for ethylene will not change much in 1985. Polymers will continue their slow gain in the share of total consumption at the expense of some of the smaller uses such as chlorinated derivatives used as solvents.



Propylene

- **Production up a bit**
- **Capacity flat**
- **Prices down**

PRODUCTION/CAPACITY



MAJOR PRODUCERS

Amoco Chemical, Arco Chemical, Dow Chemical, Exxon Chemical, Shell Chemical

HOW MADE

Recovered from cracked gas streams from steam crackers and refinery catalytic cracking units

MAJOR DERIVATIVES (U.S.)

Polymers 35%, acrylonitrile 20%, propylene oxide 10%, cumene 10%

MAJOR END USES (U.S.)

Fabricated plastics 50%, fibers 15%, solvents 15%

FOREIGN TRADE

Exports—negligible, imports—holding at about 500 million lb for 1985

PRICES

Chemical grade 16 cents per lb, polymer grade 17 cents per lb

The outlook for propylene has at least one similarity to that for ethylene—a nearly complete halt in production growth during 1985 after a major recovery in 1984. Production of all grades of propylene in 1985 will be up slightly to about 15.7 billion lb from about 15.2 billion lb last year. This covers all uses of propylene for making chemicals and polymers, but excludes refinery uses for making gasoline components such as alkylate. The production gain of slightly more than 1% compares with a nearly 11% gain in 1984, the slowdown resulting from more severe competition in many export markets for U.S. propylene derivatives.

Most polypropylene derivatives are made from chemical and polymer grades of propylene. A few exceptions use "refinery grade," whose propylene content may range from 35 to 90%. Gasoline components also use refinery-grade propylene, thereby acting as competition for chemical uses. These uses also are in competition with the upgrading of the refinery-grade propylene stream for use in making derivatives.

Roughly two thirds of propylene is produced in refineries, mainly in fluid catalytic cracking units; the other third is produced as a coproduct of ethylene in steam crackers. Practically all of the propylene made in steam crackers is used to make chemical and polymer derivatives and an important part of refinery propylene also is used for derivatives. Except for the relatively small quantity of derivatives made directly from refinery-grade propylene, most refinery-grade propylene used for derivatives must first be purified at a significant cost. The purification cost also makes the economics of derivative manufacture favor use of coproduct propylene wherever possible.

Sufficient propylene capacity exists to meet demand if that available from refinery operations is included. But propylene must be priced high enough to justify its being drawn away from the

fuel uses. This capacity could be expanded, if returns on investment are sufficient, because cracking units in refineries produce more propylene than now is purified or used directly in making derivatives. However, there is a limit to the quantity of propylene available at any time because the refinery cracking units are operated to make gasoline and other fuel components, and not to make propylene.

Shifts in operation of steam crackers and of refineries have led some derivatives producers to sound an alarm about a possible shortage of the chemical and polymer grades of propylene. This alarm has caused higher prices of propylene relative to ethylene. Ten years ago, a rough rule of thumb was that the price of propylene was 70% that of ethylene. Now propylene prices are the same as ethylene prices or slightly higher, reflecting the apparently less plentiful supply.

The causes of the current rough parity in prices for ethylene and propylene come from the economic squeeze of the early 1980s. The economic recession led steam cracker operators to adapt to the lowest-cost feedstocks, largely ethane, to make ethylene at lowest possible cost. At the same time, refinery operations were cut back, because of lower demand for fuel products. More recently, imports of fuel products have further reduced refinery operations.

However, no real long-term shortage of propylene is expected by industry sources. Even without steam cracker operators changing to heavier feedstocks to raise propylene yields to meet demands, more propylene could be taken from refinery fuel uses, if prices were to rise.

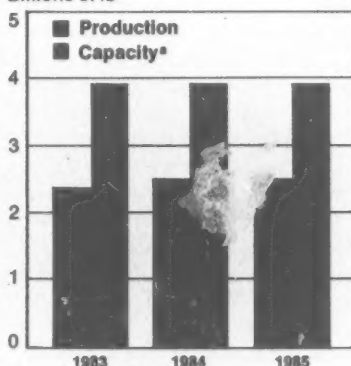
The conditions of propylene prices and supply aren't expected to have any major impact on manufacture of derivatives. As is the case with ethylene polymers, polypropylene will grow faster than will most other propylene derivatives and will take a slowly growing share of propylene consumption.

Butadiene

- **Production limited**
- **Capacity large**
- **Prices holding**

PRODUCTION/CAPACITY

Billions of lb



a First quarter; extraction capacity; includes shutdown capacity not expected to restart.

MAJOR PRODUCERS

Amoco Chemical, El Paso Products, Exxon Chemical, Shell Chemical, Texas Petrochemicals

HOW MADE

Recovered from steam cracker product streams; dehydrogenation of butylenes from refinery catalytic cracking

MAJOR DERIVATIVES (U.S.)

Styrene-butadiene rubber 40 %, polybutadiene rubber 25 %,

MAJOR END USES (U.S.)

Fabricated rubber products 75 %, fibers 10 %

FOREIGN TRADE

Exports—holding at about 150 million lb in 1985, imports—may fall to about 600 million lb in 1985

PRICES

About 30 cents per lb

U.S. butadiene producers will be pushing plants hard in 1985, including some recently restarted units. Nevertheless, they probably will be capable of supplying less than 80% of the butadiene expected to be consumed domestically this year. Imports, growing ever more difficult to obtain, will have to make up the difference.

Production of butadiene from all sources in the U.S. will be about the same as in 1984, a little more than 2.5 billion lb. But final output will depend on a number of factors, including demand (largely for various elastomers), feedstocks sent to steam crackers, and the strength of the dollar.

Plenty of capacity exists to make butadiene, either as a coproduct of making ethylene in steam crackers or by dehydrogenation of butylenes made in refineries. This capacity is a measure of the ability of producers to extract butadiene from streams of C₄ hydrocarbons produced in the U.S. or imported. During the past two years, it has been reduced as significant quantities of capacity have been scrapped. Some of the capacity now counted in the total probably will be scrapped without ever being run again, but the "on-standby" designation hasn't yet been changed.

Except for a small amount of butadiene produced by dehydrogenation of butylenes, all butadiene consumed in the U.S. is a coproduct of ethylene manufacture. Critical to butadiene production is the feedstock used in steam crackers to make ethylene. If ethane is the feedstock, butadiene production is minimal. As feedstock to a steam cracker is shifted toward heavier hydrocarbons, the butadiene yield rises rapidly. On the average in 1984, the yield of butadiene in steam crackers was less than 8% of the ethylene yield, an output of two thirds or less of the yield of butadiene relative to ethylene in Europe where naphtha still continues to be the major steam cracker feedstock.

In Europe, the source of most buta-



diene imported into the U.S., the situation is changing. Ethylene units are being shut down and their feedstock composition is changing toward lighter hydrocarbons. All this is being done in anticipation of imports of ethylene derivatives from lower-cost feedstock sources in the Middle East. At the same time, these changes are reducing the amount of coproduct butadiene available for internal use and for export to North America and Japan.

Therefore, the current question among consumers of butadiene is whether imports will be available to meet the expected deficit in U.S. production. Countries other than in Europe have or appear to have little capability to supply much butadiene. Except for the strength of the dollar, competition could reduce this potential supply. As long as the dollar remains strong, the incentive to sell to the U.S. will remain in preference to sales to countries such as Mexico where currency is being devalued.

Prices of butadiene nevertheless might firm slightly during 1985 if demand should increase again this year following the increase in demand of more than 9% in 1984. If prices firm by a small amount as the result of perceived stronger demand in the U.S., then both imports and production could rise.

Some increase in butadiene prices has not reduced consumption gains much from what had been anticipated with the economic recovery. In 1985, some of the smaller uses such as acrylonitrile-butadiene-styrene resins may grow faster than will the major elastomer uses. This growth, slowing after a large gain in 1984, will not be large enough to change the end use pattern much. In spite of some development work with this unusual diolefin, no new uses will appear to take significant quantities of butadiene.

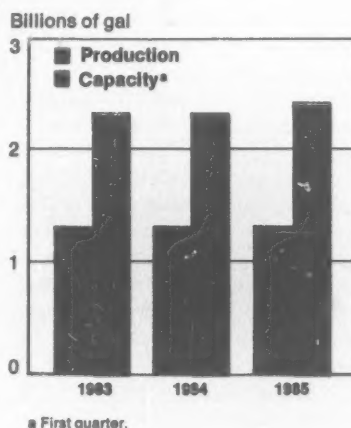
At current and expected prices for butadiene for 1985, production will just about hold steady or inch up slightly. Consumption will hold about even.



Benzene

- **Production flat**
- **Capacity holding**
- **Prices firming**

PRODUCTION/CAPACITY



MAJOR PRODUCERS

Amoco Oil, Arco Chemical, Coastal Corp., Exxon Chemical, Gulf Oil Products, Shell Oil, Sun Oil

HOW MADE

Separated from aromatic streams from refineries, olefin plants, coke ovens; dealkylation of toluene

MAJOR DERIVATIVES (U.S.)

Ethylbenzene 50%, cumene 20%, cyclohexane 15%, aniline 5%

MAJOR END USES (U.S.)

Styrenic plastics 35%, phenolic resins 20%, nylons 15%

FOREIGN TRADE

Exports—small, remaining at about 20 million gal in 1985; imports—slipping to 150 to 160 million gal in 1985

PRICES

List price \$1.17 per gal

The best news to come to benzene producers this year is a slight firming of prices. Beyond that, it's a pretty ho-hum outlook for benzene: Production probably will not grow appreciably, nor will capacity rise further following the addition of a new Sohio plant at the end of 1984.

The price firming, however, may not do enough for benzene producers. Spot prices for benzene, reflecting only a part of total sales, increased in small increments beginning in January. By early March, they were above the list price, which had dropped significantly in 1984.

These spot prices reflect mainly demand factors and feedstock conditions beyond those in the chemical industry. The spot price rise went along with firming of gasoline prices, and was related to the value benzene has in gasoline, both as a volume component and as an octane contributor to the total pool octane value. Some minor effect was felt from the drawdown of benzene inventories in 1984 and from anticipated improved demand for some end products of benzene.

During 1984, benzene prices fell more than 30 cents a gal, or nearly 20%, because of stagnant demand, lower prices for some derivatives, large inventories, and declines in crude oil prices. Spot prices ranged slightly below list prices during the second half of the year, further hurting profits from recovery and selling of benzene.

That situation changed during the first quarter of 1985. Now, questions are developing as to whether these price increases, small as they are, will hold for the rest of the year. Benzene demand in the second quarter probably will be as good as in the first quarter. Later on, demand may weaken, pulling down production as inventories build.

Benzene production for all of 1985, therefore, likely will end up about the same as in 1984, at 1.3 billion gal. This hold on production could mean that a slight decline will occur in the

operating rate for total nameplate capacity, but it essentially will remain at about the same 55% rate that it has been the past two years.

Nameplate capacity, much of which is in or closely attached to refineries, long has been considered to be well overstated. If sufficient aromatics streams could be obtained, then the nameplate capacity might nearly be reached. But even so, capacity still could be overstated because of units, long shut down at steel mills and small refineries, which are not expected ever to be run again. In addition, several relatively large benzene units currently are shut down, with questions about future operation concerning some of them.

Some small amounts of capacity have been scrapped, but during the fourth quarter of 1984, Sohio Chemical started up its new unit with a nameplate capacity of 115 million gal a year. The actual net gain in capacity for 1985 operation is hard to pin down, but probably at least two thirds of Sohio's new unit capacity should be added to the total.

Part of benzene capacity is attached to steam crackers where benzene is separated from the pyrolysis gasoline fraction of the product stream. Typically, benzene produced in steam crackers has accounted for about 25% of production, or a bit more. The other part of benzene supply—imports—could decline a bit in 1985 unless domestic prices rise. As U.S. selling prices decline during 1984, imports also decline because of little or no profit to traders in benzene. This year, imports could supply at least 10% of U.S. benzene demand, but certainly not more than 15%.

None of the major uses of benzene will show much gain in demand during 1985. One—styrene—because of imports of polymers, could decline slightly. The result, then, for benzene will be a year of minor change in production and a struggle to squeeze a bit of profit from a slight price firming.

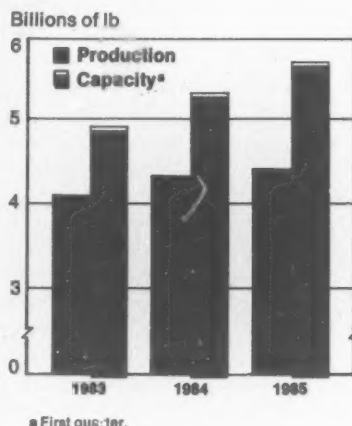
Key Chemicals

p-Xylene

- **Production may slow**
- **Capacity up a bit**
- **Prices could firm**



PRODUCTION/CAPACITY



MAJOR PRODUCERS

Amoco Chemical, Arco Chemical, Chevron Chemical, Exxon Chemical, Koch, Phillips Chemical

HOW MADE

Separated from mixed xylene streams made in oil refineries and steam cracking olefins plants

MAJOR DERIVATIVES (U.S.)

Dimethyl terephthalate 55%, terephthalic acid 45%

MAJOR END USES (U.S.)

Polyester fibers 80%, blow-molded items (mostly bottles) 10%, films 5%

FOREIGN TRADE

Exports—may exceed 1 billion lb in 1985, imports—may be greater than 100 million lb in 1985

PRICES

List price 22 cents per lb delivered

Capacity to make *p*-xylene continues to expand. It grew again in 1984. But, although that doesn't help prices or profitability for producers, it does bring a small increase to production, if for no other reason than that it increases inventories necessary to meet expected sales volumes.

Because of a net capacity increase during 1984 of about 400 million lb, output during 1985 likely will rise slightly, perhaps about 100 million lb, to 4.4 billion lb. The final figure will depend on availability to producers of mixed xylenes, on the export markets for *p*-xylene (as well as for *o*-xylene), and on the size of imports of apparel made using polyester fibers.

A production total of 4.4 billion lb of *p*-xylene in 1985, however, will not raise the plant operating rate. Nameplate capacity for this year will reach 5.7 billion lb, with all of it expected to operate to supply sales demand and inventory building as needed during the year. The actual operating rate will be about 77% on the average, down slightly from the estimated average rate of 81% in 1984.

The various factors that influence production probably will change only slightly during 1985 when growth in output will be quite close to, but probably slightly below, growth in gross national product. But these factors also could strongly influence *p*-xylene production. For example, mixed xylenes could become more expensive because of the more rapid shift toward unleaded gasoline, which results from lowered limits on use of lead alkyls, more stringent controls against misfueling of catalytic-muffler-equipped cars, and a higher percentage of cars requiring premium unleaded fuels. If demand for *p*-xylene does not remain strong enough to pay the competitive price for it to be removed from the mixed xylenes streams, then actual production could decline.

At the same time, the export demand also could change. Based on recent experience, exports for 1985

are estimated to top 1 billion lb of *p*-xylene. This estimate depends upon a growing demand for the isomer for polyester fibers and for some fabricated items in the Pacific Rim countries. It also depends upon continued production difficulties at plants in developing countries that require *p*-xylene either for their own fiber production or to fill commitments for exports made before the plants were completed.

If fiber demand in some of these countries rises steeply, partly spurred by exports of apparel to the U.S., and if operational problems get worse, export demand for *p*-xylene could soar by an additional 100 million to 200 million lb in 1985. Of course, this rise in export demand would not translate back into an equally large increase in production. Most of the additional exports of *p*-xylene would return to the U.S. as apparel, offsetting consumption of polyester fibers for apparel made in the U.S. and reducing total demand for *p*-xylene by nearly an equal amount.

With almost 80% of *p*-xylene eventually ending up in fibers made in the U.S., the outlook for fibers and apparel demand continues to be critical to total *p*-xylene consumption. In general, polyester fiber demand in the U.S. is expected to do no better than hold even. A slight decline is more likely.

But demand for *p*-xylene in making polyester bottle resins, both the polyethylene and the polybutene terephthalates, probably will increase an amount about equal to the decline in demand for use in fibers.

The result of a lower demand for *p*-xylene for making polyester fibers and a higher demand for making bottle resins could make *p*-xylene one of the few major-volume petrochemicals to show a change in its use pattern in 1985. If a change to 75% or less of U.S. consumption for fibers and to more than 15% for bottle resins doesn't occur in 1985, it certainly will in 1986.

A1250-1

APRIL 1, 1985

CHEMICAL & ENGINEERING

NEWS

Delivery Of Drugs

New systems prolong
their effectiveness

Page 30

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News of the Week

■ **CMA announces new initiatives to increase public access to hazard information about chemicals but Congress continues to call for stricter industry regulation.** Page 6

■ **NAS will honor six chemists for their contributions to science.** Page 7

■ **C&EN senior editor William F. Fallwell is dead at age 44.** Page 7

■ **Latest estimate of natural gas in U.S. recoverable by conventional methods is 784 trillion cu ft.** Page 7

■ **Cobalt and manganese can be recovered from low-grade ores in molten salt method developed at Argonne National Laboratory.** Page 8

■ **G. D. Searle takes itself off the market.** Page 8

Cover: Operator at Alza Corp. checks production of transdermal patches used for slow release of scopolamine, which combats motion sickness

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Business

Nuclear power plants pinched for space to store spent fuel could transship it to sites that have excess space. Page 11

Leveling of ethylene demand halts growth of light hydrocarbons used to make it; biotech revenues slow in fourth quarter. Page 12

International Business

European petrochemical producers nix preferential treatment for Saudis, who warn protectionism could lead to price wars. Page 14

Government

Reagan Administration move to cut back number of research grants funded by NIH may not be legal. Page 16

Document on scientific principles will guide federal agencies in assessing chemical carcinogenicity risks. Page 17

Science

AIDS epidemic continues despite expanding knowledge of its cause; blood test for antibodies faces questions of legality. Page 19

Perkin Medal

Perkin Medalist Paul B. Weisz of the University of Pennsylvania is best known for his contributions to zeolite catalysis. Page 27



Special Report

Controlled-release delivery of drugs has been a growing target of research during the past 10 years. Page 30

Academy to present awards to six chemists

Chemist Richard B. Bernstein and biochemists Martin F. Gellert, Tom Maniatis, Ira Herskowitz, Gerald M. Rubin, and Allan C. Spradling will be among 15 scientists honored by the National Academy of Sciences for outstanding contributions to science at the academy's annual meeting on April 22.

Bernstein, professor of chemistry at the University of California, Los Angeles, will receive the NAS Award in Chemical Science for his theoretical and experimental work on chemical reactivity. Bernstein uses molecular beam scattering and other laser techniques to study elastic, inelastic, and reactive collisions of small molecules and ions. His prize, which consists of \$10,000 in cash and a bronze medal, was established by Occidental Petroleum Corp. to honor Armand Hammer.

The Richard Lounsbery Award, a \$50,000 prize and an additional \$20,000 for travel, study, or other efforts, will be shared by Maniatis, professor of biochemistry and molecular biology, Harvard University,

and Gellert, chief of the section on metabolic enzymes of the National Institute of Arthritis, Diabetes, Digestive & Kidney Diseases. The researchers are being honored for their contributions to understanding the structure and function of DNA.

Herskowitz, professor of biochemistry at the University of California, San Francisco, will receive the \$5000 NAS Award for Scientific Reviewing for his focused and enlivening reviews of phage biology. Rubin, professor of biochemistry at the University of California, Berkeley, and Spradling, a staff member at Carnegie Institution of Washington, will share the \$5000 U.S. Steel Foundation Award in Molecular Biology for their development of a method to stably integrate cloned genes into the germ cells of living fruit flies.

Other awards for chemically related work will go to Steven E. Lindow, associate professor of plant pathology, University of California, Berkeley, for his research in the genetic control of ice nucleation in bacteria, and to Isidor I. Rabi, university professor emeritus, Columbia University, for his work on behalf of the peaceful uses of atomic energy. □

C&EN senior editor Bill Fallwell dies

C&EN senior editor William F. Fallwell died suddenly on March 24 in his New York City apartment. He was 44 years old.

He joined the editorial staff of C&EN in 1966. Apart from a three-year stint in Washington, D.C., as managing editor from 1981 to 1984, he spent his career in various capacities in the magazine's New York City operation.

His contributions to the magazine were legion. He was a prolific writer. And he did much to enhance C&EN's coverage of the chemical industry.

He also helped to broaden and integrate the magazine's approach to many other topics. A perceptive and analytical observer of the chemical scene, Fallwell had an acute sense of the relationships among the scientific, technical, government-

tal, and business aspects of chemistry and of their impact on society in general.

A native of Boston, he received a B.A. in chemistry from Principia College, Elmhurst, Ill. He served in U.S. Army Intelligence for three years before joining C&EN. □



Group updates estimate of natural gas reserves

The most likely magnitude of natural gas potentially recoverable in the U.S. by conventional production methods is now estimated to be about 784 trillion cu ft. If added to the 200 trillion cu ft of proved reserves remaining in discovered fields, the total resource would be more than 57 times the 1984 natural gas production of 17.2 trillion cu ft.

These are the latest estimates to come from the Potential Gas Committee, which provides a biennial evaluation and has just released a preliminary report of its analysis of the results of exploration through the end of 1984. The committee consists of individual volunteers from the natural gas industry (production, pipeline, and distribution companies), independent geologists, government agencies, and academic institutions concerned with natural gas. Although independent, it functions with guidance and assistance from Colorado School of Mines' Potential Gas Agency, which receives major support from the American Gas Association.

Although the year-end estimate for 1984 for the entire U.S. is reduced from that at the end of 1982, the estimate for one geological province—the eastern Gulf of Mexico offshore—has been increased significantly. Discoveries in this area in recent years, the committee says, have demonstrated the probability of sizable natural gas resources there. At the same time, estimates for two other provinces—the Wind River basin of Wyoming and the Wyoming-Utah-Idaho Thrust Belt, have been reduced significantly as a result of relatively recent exploratory drilling.

For its estimates, the committee includes all of the resources that it believes can be discovered and produced utilizing conventional natural gas exploration, drilling, and production technology. It also classifies the resources as probable, possible, and speculative. "Probable" are those, in addition to proved reserves, estimated to remain in undeveloped portions of fields already discov-

U.S. has 784 trillion cu ft natural gas potential

Location	Most likely amounts, trillion cu ft		
	Probable	Possible	Speculative
Onshore	150	215	191
Lower 48 states	143	199	163
Alaska	7	16	28
Offshore	35	78	115
Lower 48 states	32	65	44
Alaska	2	13	71
Total lower 48 states	176	264	207
Total Alaska	9	29	99
TOTAL U.S.	185	293	306

Note: Figures may not always add because of rounding.

ered; "possible" are those that may be found through new field discoveries within formations and provinces already known to be productive; and "speculative" are those undiscovered resources that may be found through new field discoveries in formations and provinces not yet demonstrated to be productive.

The current report represents a major departure for the committee in that it has organized its work in a way that provides much more detailed information, on a province-by-province basis. Also, starting with the current report, the committee is publishing its maximum and minimum estimates of the resource potential, as well as its estimate of the most likely potential.

The complete report, due out in June, is available for \$25 plus shipping and handling from Potential Gas Agency, Campus Box 13, Colorado School of Mines, Golden, Colo. 80401. □

Cobalt and manganese from low-grade ores

Chemists at Argonne National Laboratory have discovered a simple method for recovering cobalt and manganese from low- and medium-grade ores. The metals are extracted into a molten salt mixture, then separated from the salt mixture by electrolysis.

The new extraction method could prove advantageous in deep-sea

mining operations. It also could provide a less costly way to recover the two metals from land ores that are currently mined primarily for copper, nickel, or iron.

The process is being developed by Argonne's Victor Maroni, working with Samuel von Winbush (now at Argonne on research leave from State University of New York, Old Westbury campus).

Studies to date have focused on deep-sea nodule ores containing about 30% manganese, 7% iron, 1% nickel, 1% copper, and 0.3% cobalt. In tests at 450 °C, a eutectic mixture of sodium, potassium, and magnesium chlorides readily extracted nearly 100% of the metals. Equilibrium extraction conditions were reached with low salt-to-ore ratios—less than 3 to 1 by weight—in about an hour. The copper and iron form complexes that quickly volatilize from the molten solution. Manganese and nickel complexes also volatilize, but at a slower rate.

The extracted cobalt and manganese can be deposited on a carbon cathode at electrolysis potentials of 1.0 to 1.5 volts. By proper control of the potential, cobalt can be selectively recovered even in the presence of manganese and other transition metals.

Given the present state of the metal industries, Maroni observes, people might look at the development and say, "So what?" However, more than 90% of the cobalt and manganese used in the U.S. is imported; it's comforting to know that in a pinch the strategic metals could be obtained efficiently from North American ores. And for deep-sea mining, the process is compact enough to be carried out on ships or floating platforms, with no need to transport ore to shore for refining. Most of the salts used in the process could be recycled, and depleted ore could be returned to the ocean floor with a minimum of pollution. □

Searle no longer wants to be sold

Apparently unable to attract a high enough bid, G. D. Searle has ended its effort to sell the company either in parts or as a whole. Instead, the pharmaceutical firm will continue to operate as an independent company.

Searle began to seek a buyer or buyers last September after the Searle family, which owns some 34% of the company's stock, asked the firm's management to find ways to diversify the family holdings. Subsequently, interest in acquiring parts of the company was expressed by a number of firms, including Monsanto, which is looking for a pharmaceutical marketing organization to bolster its move into the health care field. Pfizer also talked to Searle about buying various segments including the NutraSweet (aspartame) sweetener division. In addition, Angus Chemical, along with its parent corporations Pacific Gas Transmission and Alberta Natural Gas, offered to buy the NutraSweet unit in January.

Now Searle's board has voted unanimously to keep the company intact. In a letter, members of the

Searle family wrote that they were satisfied that the decision is "in the best interests of all concerned."

Angus, expressing disappointment over Searle's decision, says it will go ahead with plans to manufacture and market aspartame produced through its own technology overseas. The company's Irish subsidiary, Angus Fine Chemicals, is building a plant due on stream late this year in Ringaskiddy, Ireland, that will make aspartame and other specialty chemicals for sale in Europe and elsewhere abroad. Searle's U.S. patent on aspartame expires in 1992.

Searle president and chief executive officer Donald H. Rumsfeld says he expects 1985 "to be a year of improved financial performance as well as a period of continued investment for the introduction and development of new pharmaceutical products" and expansion of the company's sweetener and other businesses.

At the same time that Searle announced its decision, the board also increased the company's quarterly cash dividend to 25 cents per share from 13 cents per share. □

Biotechnology revenues slowed in fourth quarter

Last year featured sharp increases in revenues for most biotechnology-based companies. For some of the firms that started up during the late 1970s and early 1980s—particularly those using monoclonal antibody technology for diagnostic and animal health products—the surge in revenues came largely from product sales. For others—including some of the largest of these companies—still lacking much in the way of products to sell, revenues grew because of added contract research and development fees.

For the year, a dozen biotechnology-based companies—representing more than three quarters of all revenues for such companies—registered a composite increase in revenues of 76% over 1983 to \$271 million. Together, these same firms wracked up a \$30 million loss, 11% bigger than the year before. There was great variation in results from company to company, however. Several firms reported earnings; less than half the group accounted for most of the losses.

In the fourth quarter of 1984, 14 firms (the above 12 plus two others) reported a composite revenue gain of 42% from fourth-quarter 1983 to \$69 million, compared to jumps of 99% and 92% in the two preceding quarters from the year-earlier periods. The composite loss for these

firms ballooned to \$49 million, 47% more than in fourth-quarter 1983. Most of the rise, however, resulted from a 341% increase in the net loss reported by Genex, which was hit hard by cost overruns in starting up a new plant and by increased competition in the aspartame precursor marketplace in which the firm's chief product, genetically engineered L-phenylalanine, is sold.

For the most part, earnings at those firms that did not report losses remain nominal, more a function of investor reassurance than an actual measure of commercial achievement. Genentech, for instance, still the biggest of the new biotechnology firms, reported a 171% jump in fourth-quarter net income to \$612,000. The company warns about attempting to find a pattern in this improvement, however.

"As in the past, significant quarter-to-quarter income and revenue fluctuations may occur during 1985 due to variations in the timing of revenues for licensing and research benchmarks," the company comments. "These fluctuations have no impact on the company's long-term growth." Genentech, in fact, is still not marketing a product of its own. Contract research, licensing revenues (mainly for human insulin), and the manufacture of clinical products for contract partners ac-

count for 94% of revenues, interest income for the rest.

Cetus also reported positive net income for the quarter of \$101,000. Very little revenue came from products, however. The breakdown: R&D fees 72%, royalties and product sales 2%, and interest and other 27%. Biogen, with a \$13.1 million loss for the year, up 13% from 1983, cut its fourth-quarter loss nearly two thirds to \$2.2 million.

"We see 1984 as the end of our first stage of development," says Mark Skaletsky, principal operating officer and acting chief executive at Biogen, since former chairman Walter Gilbert's abrupt departure last December (C&EN, Dec. 24, 1984, page 5). "Our size has stabilized, and our goal is to have a reduced loss for the full year in 1985." Much of that stabilization was achieved by laying off 13% of the company's staff last fall.

Hybritech, with a 124% increase in revenues to \$11.4 million, joined the ranks of the larger biotechnology-based firms in revenues. Hybritech is selling a number of monoclonal-based products. Similarly, but on a far smaller scale, competitor Monoclonal Antibodies, fueled by sales of its pregnancy diagnostic test kits, raised its revenues for the quarter 352% to \$1.4 million. Of that total, nearly three quarters came from product sales.

David Webber, New York

Biotechnology firm results varied widely in fourth-quarter 1984

	FOURTH-QUARTER 1984 ^a						FULL-YEAR 1984 ^b					
	Revenues ^c Earnings ^d		Change from 1983		Profit margin ^e		Revenues ^c Earnings ^d		Change from 1983		Profit margin ^e	
	(\$ millions)		Revenues	Earnings	1984	1983	(\$ millions)		Revenues	Earnings	1984	1983
Amgen	\$ 2.35	\$-1.94	20%	def	def	def	na	na	na	na	na	na
BioTechnica International	0.37	-1.18	18	def	def	def	\$ 1.37	\$ -4.39	289%	def	def	def
Biogen	9.38	-2.22	164	def	def	def	31.39	-13.13	70	def	def	def
California Biotechnology	2.17	-0.12	19	def	def	0.5%	8.28	-0.13	57	def	def	2.4%
Centocor	4.10	0.36	71	nm	8.7%	def	12.84	0.70	73	nm	5.5%	def
Cetus	13.25	0.10	25	-65%	0.8	2.7	59.54	0.83	61	nm	1.4	def
Collaborative Research	2.12	-1.17	51	def	def	def	na	na	na	na	na	na
Damon Biotech	1.11	-1.96	2	def	def	def	5.08	-5.03	57	def	def	def
Genentech	18.13	0.61	35	171	3.4	1.7	69.79	2.72	48	141%	3.9	2.4
Genex	1.30	-7.50	-72	def	def	def	34.80	-7.40	214	def	def	def
Hybritech	11.39	0.00	124	-96	0.0	0.5	33.70	0.37	112	nm	1.1	def
Molecular Genetics	2.10	-0.65	8	def	def	6.4	9.22	-0.64	33	def	def	7.9
Monoclonal Antibodies	1.36	-1.07	352	def	def	def	4.29	-3.57	261	def	def	def
Ribi ImmunoChem	0.16	-0.10	-9	def	def	def	0.91	-0.29	36	def	def	def

^a For three-month period ending closest to Dec. 31. ^b For 12-month period ending closest to Dec. 31. ^c Includes sales, contract research, royalty, and interest revenues. ^d Excludes extraordinary credits. ^e After-tax income as a percentage of revenues. na = not available. nm = not meaningful. def = deficit.

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News of the Week

■ **Federal support for basic research in chemistry in fiscal 1986 budget is favorable but that for applied research is a mixed bag.** Page 6

■ **Panel of pesticide makers, environmentalists draws up guidelines for labeling containers of pesticides being exported.** Page 7

■ **TVA is testing a one-step process to beneficiate low-grade phosphate rock.** Page 7

■ **Rockefeller University and Weizmann Institute will collaborate on research projects under \$5 million foundation award.** Page 8

■ **Union Carbide is finding it difficult to renew its public liability insurance with the same amount of coverage it had before Bhopal.** Page 8

■ **A. H. Robins sets up \$615 million reserve for lawsuits stemming from use of the Dalkon Shield.** Page 8

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Picture Agency, Washington, D.C.

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Business

EPA's reduction of lead use limits in gasoline opens the door for producers of alcohol fuels ethanol and methanol. Page 17

Chemical capital spending rose sharply during fourth-quarter 1984 and capital appropriations gained accordingly. Page 18

Government

House subcommittees discuss survey of emissions of U.S. chemical companies, Carbide's report on Bhopal accident. Page 20

Science

Refining reactor, technique for metal-atom/free-radical route to sigma-bonded metal alkyls expands method to most metals. Page 23

Scientists representing CHEMRAWN II committee brief Sri Lanka officials on the country's agricultural R&D needs. Page 25

Education

Directory of Graduate Research has been computerized, allowing users to make data searches and correlations easily. Page 26

Technology

Ultrasoft x-ray fluorescence spectroscopy (USXFS) is a new tool to obtain depth profiles of films from 50 to 5000 Å thick. Page 28

Books

"Beyond Dumping" presents viable alternatives to putting toxic wastes in landfills—such as detoxifying and recycling. Page 31



News Focus

The Bhopal disaster has led to extensive re-examination of chemical development and safety in poor countries. Page 9

CHEMICAL R&D: Outlook fair for federal funding

The outlook for federal support of basic research in chemistry in fiscal 1986—particularly research conducted at academic institutions—is favorable, considering current budget pressures. However, support for applied research in chemistry varies across the mission agencies, showing a mix of increases, level funding, and decreases.

Those are the conclusions contained in an American Association for the Advancement of Science analysis of the proposed federal research budget for fiscal 1986, released last week at a colloquium in Washington, D.C. The analysis of the chemical R&D budget was prepared by Annette T. Rosenblum and Mary Wolfe of the American Chemical Society's Department of Government Relations & Science Policy.

At the National Science Founda-

tion, the report notes that funding for the chemistry division is proposed to rise 7% to \$93.5 million in fiscal 1986. The agency's goal is to support the same number of scientists, 875, but to increase the average grant size from \$86,965 to \$91,667. Funding for chemical instrumentation is set at \$11.5 million, with \$2 million earmarked for maintaining the nine regional instrumentation facilities. Foundation-wide support for chemistry is set to increase 6% to almost \$208 million.

Department of Defense support for basic chemical research is up 11% to \$74.7 million in the proposed budget. About \$40.9 million is designated for chemical research under the auspices of the Army, Navy, and Air Force contract offices. Universities and colleges, the analysis says, will receive about 86% of that chemistry money. But it warns that these numbers may be "soft"—they are estimates that have been revised often in the past.

Overall support for chemistry programs by the Department of Energy is expected to rise 3% to \$245 million, even though funding for the chemical sciences program would be frozen at the fiscal 1985 level of \$79.5 million. Of the \$20 million slated for chemical research under the fossil energy program, the analysis says that 10% appears destined for academic institutions, with most of that funding coming from the advanced research and technology development subprogram.

In DOE's biological and environmental research program budget proposal, funding for acid rain research remains unchanged at \$6.5 million. Research to develop advanced radiation and analytical instrumentation continues at \$5.9 million, and the \$2.1 million earmarked for research in chemical physics will

be used to investigate molecular relaxation phenomena. About 70% of the unchanged budget for energy storage, or \$13 million, is targeted for chemistry research. Of that amount, about \$4.3 million will go directly to universities.

At the Environmental Protection Agency, the report notes that much of the proposed 9% rise to \$230 million in research involving chemistry is the result of a 61% increase to \$60.5 million in acid rain research funding. Of the extramural research programs involving chemistry, hazardous waste is slated for a 36% increase to \$33 million and pesticides research a 74% increase to \$43.3 million.

Funding for the Department of Agriculture's eight major research centers is expected to be up less than 1% to \$157 million, the analysis says, with the chemical research effort appearing to decrease from the 1985 level. The opposite is true at the National Bureau of Standards, where the overall proposed budget is down, but the programs that traditionally fund chemistry are up 40% to \$10 million.

The budget proposal for the National Institutes of Health was not overlooked in the analysis of chemical research funding. However, it is the hardest one to pin down, because programs supporting chemistry are not budgeted separately at NIH. Thus, total yearly support for chemistry can be determined only in retrospect. However, it is assumed that support for chemistry moves in proportion to the overall budget—thus chemistry also should expect a 2% increase in funding.

Copies of "AAAS Report X: Research & Development, FY 1986" can be obtained from the AAAS Sales Office, 1515 Massachusetts Ave., N.W., Washington, D.C. 20005. □

Direct federal support for chemical research is up 8% . . .

\$ millions	1985 ^a	1986 ^a	1985 ^b	% change 1985-86
NSF	\$147.4	\$137.8	\$127.7	7%
Energy	102.1	101.1	96.6	0
Defense ^c	74.7	67.0	61.7	11
NBS	10.0	7.2	6.5	39
TOTAL	\$334.2	\$313.3	\$292.5	8%

. . . and programs that include some chemistry funds are up 5%

\$ millions	1985 ^a	1986 ^a	1985 ^b	% change 1985-86
EPA	\$220.9	\$210.8	\$169.0	9%
Energy	166.0	150.4	147.9	4
Defense ^c	72.6	64.9	65.0	12
NSF	60.4	57.2	52.5	8
NBS	35.6	42.3	38.5	-16
TOTAL	\$554.5	\$525.4	\$472.9	5%

^a Estimates. ^b Actual. ^c Funds are those classified under budget category 6.1, designated for basic research. Note: NIH funding for chemical research not included because it is not budgeted separately. Source: American Chemical Society

Lead Cut Gives Alcohols Crack at Gasoline Blend Market

EPA's sharp phasedown in lead consumption in gasoline paves way for methanol and ethanol use to supply needed octane requirements

Two recent actions by the Environmental Protection Agency have given alcohol fuels—methanol and ethanol, primarily—a golden opportunity to crash into the alcohol-gasoline blend market in a big way.

Last month, EPA issued its final rule on lead phasedown (C&EN, March 11, page 8). Under it, the maximum allowable lead content of leaded gasoline will drop from the current 1.1 g per gal to 0.1 g per gal by Jan. 1, 1986, with an interim standard of 0.5 g per gal effective July 1. That's a 91% reduction in allowable lead content.

Something else, obviously, will have to be used to supply the octane that can no longer be obtained with lead additives. Alcohol producers are hoping that their product will be one of the alternatives.

Earlier this year, EPA also granted Du Pont a waiver from the Clean Air Act for a new blend of methanol, other alcohols, and unleaded gasoline. Because one of the "other alcohols" could be ethanol, the Du Pont waiver was heralded as the springboard into the fuel market for both methanol and ethanol.

Recently, representatives of the alcohol fuels industry met in San Antonio to discuss what these two EPA developments mean for their products. Attendance at this fourth annual meeting sponsored by Alcohol Week was the largest and, arguably, the most enthusiastic ever. But delegates were left like the long-

lost nephew who just discovered that he was in his aunt's will. They know that they will get something. They just don't know how much.

Initial euphoria over the Du Pont waiver has been tempered by the restrictions that EPA placed on it. EPA granted the six requirements requested by Du Pont. But it also imposed two restrictions of its own, one of which threatens to limit severely the waiver's market impact.

In accordance with Du Pont's request, maximum methanol content is limited to 6% (by volume) with minimum cosolvent volume of 2.5%. Cosolvents are limited to ethanol, propanols, butanols, or any mixture of them.

The controversy concerns EPA's added requirement that the finished fuel meet certain volatility specifications as measured by its Evaporative Index (EI) in addition to the normal Reid Vapor Pressure (RVP) requirements. Almost everyone in the industry agrees that this restriction is so severe that very few refiners or blenders will be able to

produce a finished fuel blend that can meet the specifications. As a result, the Du Pont waiver may not become the dynamic marketing tool that many thought it would be.

Ironically, the EI concept of measuring volatility was developed at Du Pont. But Edward N. Cantwell, now a consultant but who developed EI when he was at Du Pont, says that EI shouldn't be used for control purposes.

As a result of the EI restriction, Cantwell believes that the Du Pont waiver is limited to no more than 10 to 15% of the gasoline market. "We didn't get a lot when we got that waiver," he says. Cantwell adds that the market potential under the Du Pont waiver could be multiplied if the EI regulations were less restrictive. That could happen. The Oxygenated Fuel Association (OFA) has petitioned EPA to reconsider the terms of its Du Pont waiver, particularly the EI restrictions.

Robert E. Reynolds, marketing manager for New Energy Co. of Indiana, agrees that the EI require-

Lead phasedown could mean huge market for alcohol fuels

	Gasoline demand		Lead consumption		Reduction in lead (billions of grams)	Alcohol equivalent ^b (billions of gal)
	Total (billions of gal)	Unleaded ^a (billions of gal)	Old rules (billions of grams)	New rules ^a (billions of grams)		
1985	100.6	32.2	44.3	25.8	18.5	3.70
1986	100.3	28.8	41.3	2.9	38.4	7.68
1987	100.0	25.6	38.4	2.6	35.8	7.16
1988	99.6	22.4	35.6	2.2	33.4	6.68
1989	99.3	19.2	32.8	1.9	30.9	6.18
1990	99.0	16.4	30.4	1.6	28.8	5.76
1991	99.0	14.9	27.8	1.5	26.3	5.26
1992	99.0	13.4	27.2	1.3	25.9	5.18
1993	99.0	12.4	26.4	1.2	25.2	5.04
1994	99.0	11.5	25.7	1.1	24.6	4.92
TOTAL	994.8	196.8	329.9	42.1	287.6	57.56

^a Assumes no illegal fuel switching (leaded for unleaded). ^b Assumes that 1 gal of alcohol is equivalent to about 5.0 g of lead in terms of the level of octane boost achieved. Source: Herman & Associates based on Environmental Protection Agency data.

ments limit the usefulness of the Du Pont waiver. But he does see some positive signs. First, he says, it signals that it is possible to obtain additional waivers for oxygenated fuels. And he calls the Du Pont waiver the closest thing the industry has seen to a generic waiver. That's because it allows various combinations of cosolvents to be used, alone or in combination.

Like its Du Pont waiver, EPA's new lead phasedown rules probably will give a boost to market demand for the fuel alcohols ethanol and methanol. But as with the Du Pont waiver, nobody seems able—or willing—to put precise figures on the market potential.

Theoretically, at least, the market potential for alcohols, as a result of lead phasedown, is tremendous. Marilyn J. Herman, president of Herman & Associates, Washington, D.C., gave some indication at the San Antonio meeting. Working with EPA data, Herman says that the new lead rules will reduce lead use in gasoline between the second half of 1985 and 1995 an additional 288 million g more than it would have

dropped had the old regulations prevailed.

If refiners replaced all of that lead with alcohols alone to obtain the required octane, they would need 57.6 billion gal of alcohol, says Herman. Of course, refiners have no intention of using only alcohols to make up their octane deficit.

Many refiners will make capital investments in octane-producing processing units. Reforming will be a priority, followed possibly by isomerization and alkylate production. Some refiners will look to the aromatics—benzene, toluene, and xylene—and others will turn to methyl *tert*-butyl ether (MTBE). Alcohols will have plenty of competition for the octane market.

In addition to this competition, alcohols still face tremendous marketing problems in penetrating the octane market. But the EPA lead phasedown regulations and the Du Pont waiver give them their best shot at cracking the market in large volumes. The problem is that nobody really knows with certainty what those volumes will be.

Earl Anderson, New York

Chemical capital spending shows strong gains

Chemical capital spending took a sharp upturn in the fourth quarter of 1984 and for the full year, according to the Conference Board. And capital appropriations (monies that companies plan to spend in the future) also rose sharply, indicating that capital expenditures may well continue to increase in the next few years.

But neither measure achieved the vitality shown in the early 1980s. Chemical plant capacity utilization is still hovering in the low 70% range, according to government data, obviating the need for new chemical plants and limiting capital spending largely to the modernization of existing facilities.

According to the Conference Board, a New York City-based business research group, capital spending for chemicals and allied products in the fourth quarter totaled a seasonally adjusted \$3.03 billion, up 15% from the previous three months. This is the largest quarter-to-quarter

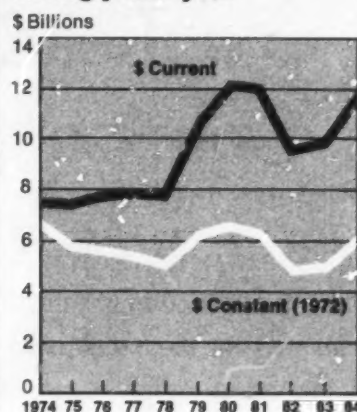
increase since the first three months of 1974.

At the same time, capital appropriations shot up 18% to \$3.33 billion from the third quarter, thus ending the year on a strong note. And the appropriations in the fourth quarter are the greatest since the third quarter of 1981, when companies appropriated \$3.39 billion.

On a constant-dollar (1972) basis, capital appropriations in the fourth quarter climbed 20% from the third quarter to \$1.70 billion, a better performance than in current dollars, indicating some disinflation. Similarly reflecting disinflation, constant-dollar capital expenditures rose 17% to \$1.55 billion, compared with the 15% rise in current dollars.

Year-to-year, chemical capital appropriations in the fourth quarter were 25% higher than in the similar period a year earlier. That follows a 4% drop in the third quarter. In constant dollars, fourth-quarter planned spending was up 26% from

Spending plans recovered strongly last year



Source: Conference Board

the 1983 period, following a 5% drop in the third quarter of last year.

Actual capital spending in current dollars was up 30% in the fourth quarter, compared to fourth-quarter 1983, following an 11% year-to-year increase in the third quarter. Constant-dollar spending in the fourth quarter was up 32% from a year earlier, following a 10% annual rise in the third quarter.

For the full year 1984, capital spending totaled \$11.2 billion, up 20% from 1983. Although that's a substantial increase, spending still remains below its historic high of \$11.7 billion in 1981. In constant 1972 dollars, capital spending last year totaled \$5.72 billion, up 20% from the year before, but 7% below the historic high in 1981.

Meanwhile, capital appropriations last year were \$11.9 billion, also an increase of 20% over the year before, but only 2% below the historic high of 1980. Constant-dollar appropriations, too, rose 20% last year to \$6.13 billion, but that is still almost 9% below its historic high in 1980. In spite of the strong recovery in 1984, real-dollar appropriations are still nearly 9% less than levels of a decade ago.

With the large increases, it may be that the chemical industry is finally joining the rest of industry, where capital spending has been rising fairly strongly for the past couple of years, a situation that the Conference Board says will continue through 1985. □

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CHEMICAL

Producers face
shrunk market
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News of the Week

■ India sues Carbide in U.S. federal court for damages resulting from Bhopal. **Page 6**

■ EPA fines Chemical Waste Management for mishandling PCB wastes. **Page 7**

■ Powerful Nova laser dedicated at Lawrence Livermore National Laboratory. **Page 7**

■ Carbide buys STP Corp., drops out of Petrosar. **Page 7**

■ NSF chooses universities to operate six engineering research centers. **Page 8**

■ Du Pont to make oxygen-barrier packaging resin in 50 million lb-per-year unit. **Page 8**

Business

Former employees of Hoffmann-La Roche fired in a mass layoff in February may file age discrimination lawsuit. **Page 12**

International Business

Association of Petrochemical Producers in Europe established to provide structured, organized voice for the industry. **Page 15**

Government

The budget is top current consideration for Congress; pesticide regulation, chemical weapons program also on agenda. **Page 18**

EPA aims for measurable environmental results, targeting sewage treatment, air and water pollutants initially. **Page 20**

Science

Advisers to UN's International Center for Genetic Engineering & Biotechnology emphasize scientific excellence. **Page 23**

First acetylenic esters synthesized, by researchers at University of Utah, likely to have important chemical properties. **Page 26**

Cover: Photo by William C. Blizzard/Uniphoto
Picture Agency, Washington, D.C.

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Product Report

Markets for rubber-processing chemicals are leaner than in the 1970s—smaller cars and tires, a drop in exports, and a rise in imports led to the squeeze. **Page 33**

Age Discrimination Suit Brewing Against Hoffmann-La Roche

Lawsuit stemming from company's February layoff may be filed next month and could be one of the largest age discrimination claims ever

David Webber, C&EN New York

The elimination of at least 1000 positions 10 weeks ago was the first mass layoff in Hoffmann-La Roche's history, and there is little doubt the company would like to put the traumatic event behind it and move on. Whether the increasingly bitter group of former employees will slip easily into Roche's past, however, is another question. It now seems likely that a potentially sizable number of them will charge the company with age discrimination. Many of those terminated are chemists and

other technical personnel, but Roche declines to reveal how many.

A number of those affected by the Feb. 4 staff cut (C&EN, Feb. 4, page 7) have formed a group called Roche Age Discriminatees Asking Redress (RADAR) to organize a class-action age discrimination suit against their former employer. The group—open to any of those fired who are over 40 years old—intends to sue Roche for back pay and for whatever difference there is between individual members' future earnings and what their income would have been had the jobs not been eliminated.

RADAR already has taken the first steps toward such a suit. In March, one member filed an age discrimination complaint in the Newark, N.J., office of the Equal Employment Opportunity Commission (EEOC), the group says. This was done to satisfy a requirement that plaintiffs who want to take their

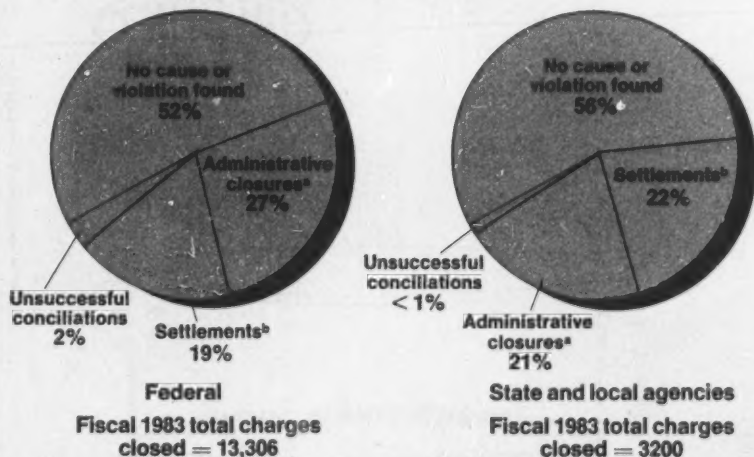
case to federal court first submit their charge to EEOC, a federal government agency, and wait 60 days. A member of RADAR's steering committee says that when that period expires in May, the group will add on the names of other aggrieved former employees and almost certainly file a suit in federal court.

The steering committee member says RADAR believes some 65 to 70%—a disproportionate share—of those dismissed are between 40 and 70 years old, the age group protected by the federal Age Discrimination in Employment Act. Evidence of this is purely anecdotal at this point, however. Terminated employees interviewed by C&EN say that former Roche staff members attending the company's outplacement assistance centers, for example, are overwhelmingly in the over-40 bracket. RADAR expects to obtain data on the age distribution of the mass layoff through the legal process.

Another statistic that might emerge in the legal process is the exact number of those dismissed. Some terminated employees put the total considerably higher than the figure of "approximately 1000" made public by the company. Based on what they say is information from sources remaining in Roche's employ, many of those fired believe that in reality between 1200 and 1600 jobs were eliminated. Roche, in the meantime, refuses to disclose any breakdown of the dismissed group—whether by age, work location, or type of duties—and stands by its rough total of 1000.

Although many of the former employees' charges are little more than guesses at this point, they reflect the depth of anger felt against a former employer once emblematic of a stable work environment. All of those interviewed—managers and

Most age discrimination charges filed in government agencies are unsuccessful



chemists with Roche experience ranging from 14 to 28 years and a minimum age of 51—believe they were singled out for dismissal because their salaries, in general, were higher than those of younger employees. They deny Roche's assertion that jobs were eliminated on the basis of superfluity. The pattern of dismissals, they say, was instead generally one of seniority.

There is also dissatisfaction with Roche's severance package. Chemists in the group dismissed, for example, point out that the chief compensation element—one week's pay per year of service—does not meet the guideline for mass layoff severance pay set by the American Chemical Society, which calls for two weeks' pay per year of service. And many complain that the outplacement assistance, though of great help in preparing the résumés of people who have not been in the job market for decades, is not likely to find them new positions at their age.

To date there is no indication of how well the terminated employees are faring in their job searches. A Roche spokeswoman says the company doesn't know; although individual success has been reported, there is no tracking system in place. She says, however, that the career centers have been well attended and that the outplacement assistance personnel "seem quite encouraged."

Many of those dismissed, on the other hand, seem discouraged. Although still looking for jobs and, in many cases, still regarding an age discrimination suit as a last, rather than first, resort, they admit to being more than a little demoralized by the common belief that people over age 55 or so have an extremely difficult time finding employment of equal rank and salary to what they had. They are not cheered by results of a survey published last December by the New York and North Jersey sections of ACS. Of those who responded to a questionnaire mailed to members who had been involved in recent years in a layoff or early retirement, there were, for example, 74 chemists aged 40 or above. Only 28 had found a new job; average time spent finding a new posi-



Cohen: proof is the tough part

tion ranged from seven to 11 months. Only five of 23 in the group over 60 years old found another job.

Former Roche employees who were interviewed for this article point out that any reluctance they might feel at this point toward joining RADAR's planned lawsuit has little to do with any fundamental aversion to litigation and nothing to do with any vestigial loyalty to Roche. They are worried about blackballing, they say. Some, in fact, are applying for openings at Roche for lower salaries and want to wait until they find out whether they will be rehired or not. And they worry that involvement in a class-action suit could prejudice attempts to find employment with other companies. These fears, whether well grounded or not, are widespread; every terminated employee interviewed requested anonymity.

Ultimately, RADAR expects many if not most of those over 40 who were fired to join the lawsuit. What success they will have with such a suit, on the other hand, seems less certain. Although age discrimination litigation is apparently increasingly common, legal experts say, it remains a difficult charge both to press and to prove.

The basic goal of an age discrimination claim is money to make up for lost wages and either reinstatement in the prior position or money to make up for differences in earning power since losing it. Those

who believe they are victims of age discrimination can pursue redress along two general courses: through federal, state, or local government agencies or through private litigation in federal or state courts. Which one they choose—or end up in—has to do with a welter of procedural, legal, and financial considerations.

Because of a recent court ruling, anyone seeking redress in the federal arena must first file a claim with EEOC, the independent body that is charged with handling all types of employment discrimination cases. EEOC then begins investigating the claim, working toward a determination of whether the agency will seek restitution for the claimant.

For an individual claimant, the advantage of letting EEOC handle a case is largely financial. It is possible to pursue the claim without hiring an attorney. On the other hand, the agency has a reputation for inefficacy.

"The problem is simple," says Leonard N. Flamm, partner at Hockett & Flamm, a New York City law firm that specializes in discrimination law. "EEOC is woefully understaffed. There are huge delays, and they only selectively process complaints."

Indeed, in the most recent year for which statistics are available (fiscal 1983), EEOC achieved settlements in fewer than one out of every five cases it disposed of in that 12-month period. The agency found no violation in more than half the cases and closed out nearly all the rest for administrative reasons.

State agencies get slightly higher marks from lawyers in the discrimination law field. In fiscal 1983, for instance, they achieved settlements in a somewhat greater percentage of cases than the federal body did. And, says Arnold S. Cohen, a partner at Oxfeld, Cohen & Blunda, Newark, N.J., speaking specifically of the New Jersey Division of Civil Rights, "they're more inclined to go ahead with a case than EEOC." The reason: relatively better funding.

Still, lawyers say the best avenue is a federal court suit. "All things being equal, a federal lawsuit is far and away the most effective reme-

dy," says V. Pamela Davis, a partner at Lane, Felcher, Kurlander & Fox in New York City. "The federal courts are faster, of better quality, get to trial more quickly, and the damages available under federal law are much greater than those available at EEOC or state court."

Flamm agrees, pointing out that federal courts provide plaintiffs an "indubitable" right to jury trial (nearly always considered an advantage to plaintiffs in such cases), the potential for double damages if "willful" discrimination can be proved, judges more experienced in age discrimination cases, and a greater body of case law.

On the other hand, going to court means hiring a lawyer, a prospect that can be especially daunting to someone who has just lost his or her livelihood. It is thought by many, in fact, that just this aspect discourages most people who would otherwise claim age discrimination. Furthermore, because of the uncertainty involved in such litigation, attorneys are generally unwilling to take a case on a contingency basis. That means a plaintiff must pay hourly rates. And, Flamm notes, it is not always easy to find an experienced discrimination law attorney because of the uncertainty of winning, the likelihood of extensive delaying tactics by the better-funded corporate defense attorneys ("they can deep-pocket the plaintiff's lawyer to the point of exhaustion," he says), and because discrimination law is complicated and little taught in law school.

In an age discrimination trial, a plaintiff has to prove first that he or she was fired despite being qualified. At that point, the defendant employer then has the burden of proving that there was a nonage-related business reason for the termination such as an economically motivated job cutback or lack of performance by the plaintiff. It is then up to the plaintiff to show that the defendant's declared rationale was a pretext. "That's the really tough part," says Cohen.

"The biggest problem is proving age discrimination," agrees Davis of Lane, Felcher. "It's getting harder and harder to prove, because employers are much more aware of it

and more careful about what they say and do."

Not only are employers less likely now to say anything blatantly discriminatory about older staff, many have instituted more frequent, more heavily documented performance reviews. For employers, a series of reviews showing declining productivity can be powerful evidence in court. It is not a sure-fire defense, however. In some cases, plaintiffs have argued successfully that reviews were skewed to mask an age-motivated layoff.

By and large, discrimination lawyers do not believe that companies are merely becoming canny about cloaking age discrimination. They think that, because of both greater awareness of the issue and the threat of financial penalty, most are less likely to discriminate now either intentionally or by blunder. Still, at the same time that actual age discrimination may be diminishing, lawyers are receiving an increasing number of such cases. This growth is probably a function of several concurrent developments: the many mass layoffs of recent years, greater knowledge by employees of their legal rights, a gradually accumulating record of courtroom success, and a more favorable judicial climate for plaintiffs.

A half-dozen years ago, comments Flamm, age discrimination suits elicited a "general judicial distaste." Judges typically considered plaintiffs malcontents and their suits logjams in the court calendar, he says. The increasing number of cases, however, has convinced the judiciary that such suits are here to stay, Flamm says, and has resulted in a greater tolerance of the suits.

This trend has helped plaintiffs' lawyers raise the importance of front pay as a compensatory addition to back pay, the traditional award in age discrimination suits. Customarily in the past, employers losing in court were ordered to offer the former employee reinstatement in his or her former position. Psychologically, however, this solution to the problem of future earnings was always fraught with complication. Recently, therefore, courts have become more receptive to the front pay alternative, typically bringing

in employment compensation experts to calculate the difference between what a plaintiff would have made in a prior job and what will be earned elsewhere.

In addition, Flamm points out, the class-action age discrimination suit—like the one being planned by RADAR—is growing more common. The explosion of mass layoffs since the mid-1970s has created more groups of former employees with common grievances. Also, a class-action approach has a simple advantage for claimants: It greatly reduces each individual's legal cost.

Like most litigation, Flamm says, "the overwhelming number of age discrimination cases get settled" somewhere between the courthouse steps and the judge's chambers. Judges, he says, have become increasingly ready to pressure the two sides into a settlement to avoid trying such cases, which are typically long and drawn out.

There is a good reason many a plaintiff settles: It may be his or her best shot at any compensation at all. "If you consider a settlement a win, then you win more than half the time," says Cohen of Oxfeld, Cohen. "When you go to trial, you prevail probably less than 50% of the time."

All the difficulties of pressing an age discrimination suit might have been more discouraging to the former Roche staff members did they not have an example of success taken from familiar surroundings. This is Erwin Klingsberg, whose age discrimination suit settlement against his former employer, American Cyanamid, seems to be known by everyone let go by Roche. Klingsberg, fired at age 60 in 1981 after refusing an early retirement offer, settled with Cyanamid this January for a "low six-figure sum." Through each stage of his case and since, he has been a passionate advocate of the rights of older employees, arguing that age discrimination is an issue that, because of employee fears and confidentiality provisions, has been unexposed for too long.

"It's an absolute fact that companies are violating the law," he asserts. "It's just a matter of firing an old guy. These companies think they can get away with murder." □

Rubber Chemicals Face Smaller Market

Stephen C. Stinson, C&EN New York

As the U.S. rubber industry resumes normal growth after a long recession in the early 1980s, U.S. suppliers of organic rubber-processing chemicals find themselves doing business in a world that looks very different from that of the 1970s.

First, restructuring of the automotive and tire industries, which consume 65 to 75% of all rubber in this country, has much reduced the domestic market for these chemicals. Even if there are no further recessions, the projected 2% annual growth will take until the late 1990s before U.S. production of rubber-processing chemicals reaches the prerecession high of 180,000 metric tons in 1979.

Second, continuing strength of the dollar makes the U.S. market vulnerable to imports, while threatening the traditionally strong export trade. Moreover, plant capacity use

among foreign producers of rubber-processing chemicals is lower than in the U.S., making this country attractive to redoubled sales efforts. Imports have grown steadily over the past decade and could reach 13,000 metric tons in 1985, which is 9% of consumption. Exports have risen and fallen with the world economy and may continue at more than 21,000 metric tons this year, which is 14% of production.

Overall, the 20 or so U.S. producers can look forward to making

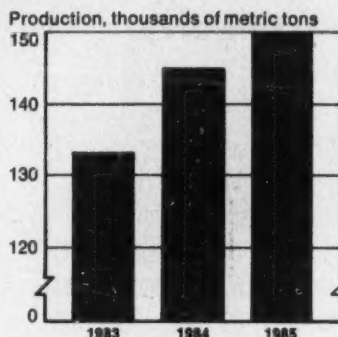
150,000 tons of organic rubber-processing chemicals in 1985, valued at \$525 million. This represents a 3% increase over 1984 levels, which in turn were almost 10% greater than in 1983.

One indication of the complexity of this industry is that production will be spread out over about 125 different chemicals. Another indication of complexity is that in addition to large sales to a dozen domestic tire companies, the industry also will service the needs of hun-



*Uniroyal technician
carves new tread
design on a blank tire*

Organic rubber-processing chemicals at a glance



Uses: Accelerators, activators, and vulcanizing agents 26%; antioxidants, antiozonants, and stabilizers 58%; other 16%

Foreign trade: Exports, 14% of production. Imports, 9% of consumption

Prices: Average \$1.59 per lb

Commercial value: \$525 million for 1985 U.S. production

dreds of manufacturers of nontire rubber goods.

Illustrative of the specialized nature of the industry is that if the 125 organic rubber-processing chemicals were all one substance, the volume would not be great enough to make C&EN's list of the Top 50 Chemicals, ranked by volume pro-

duced. Alternatively, if one company sold that dollar amount as its sole business, that firm would be 59th among chemical producers ranked by chemical sales. According to the International Trade Commission, 86 of these rubber-processing chemicals have only one U.S. producer each, 24 chemicals have only two producers, 12 have three producers, two have four producers, and only one is made by as many as five companies.

But the changes of the 1970s have taken their toll on the domestic rubber-processing chemical industry. For 1983, the last year for which data are available, the International Trade Commission listed 125 chemicals in this category, produced in the U.S. by 21 companies. In 1973, by contrast, ITC listed 166 chemicals made by 30 firms.

The restructuring of the auto, rubber, and processing chemical industries began in 1973 with the escalation of oil prices. As feedstock prices tripled, one of the first effects was that natural rubber became more competitive against synthetic rubber for the first time since World War II.

Natural rubber contains its own antioxidant substances to protect it during fabrication. Increasing use of natural rubber thus reduces the market for antioxidant stabilizers. In contrast with synthetics, however, natural rubber needs peptizers



Latex rubber mixture is checked for impurities by Goodyear researcher

to reduce viscosity for ease of fabrication. Natural rubber had sunk to 22% of total U.S. rubber consumption in 1973 but has since drifted up to about 27% of total use.

A second effect that added to consumption of natural rubber and changed the mix of rubber-processing chemicals was the introduction of radial tires in the mid-1970s. Tire makers use more natural rubber to make radials because of its lower heat buildup during driving. The longer-lasting radial tire also has reduced the market for replacement tires, and with it the total market for rubber-processing chemicals. Replacement tires are about 75% of total tire sales. Though radial tires are expected to capture 90% of the U.S. market by 1990, makers of rubber-processing chemicals have largely absorbed their impact.

A bright side to the advent of long-lasting radials is that they need more antioxidants and antiozonants to protect them in service. This is because even when standing still, such tires will be exposed to degrading effects of atmospheric oxygen and ozone for more years than once-conventional bias-ply tires.

Rubber-processing chemicals: a definition

The rubber-processing chemicals described in this report are the 200-odd organic substances that rubber compounders use to make vulcanized rubber products. With the exception of such goods as crepe rubber shoe soles and adhesives, raw rubber has no commercial uses. It must be extensively compounded first with specialty chemicals.

This report covers accelerators to speed the crosslinking reaction with sulfur, activators to potentiate the accelerators (sometimes called secondary accelerators), retarders to delay vulcanization, organic sulfur donors and peroxides as vulcanizing agents, peptizers for viscosity reduction, and

antioxidants and antiozonants to protect rubber in processing and afterwards in use. Rubber compounders use an average of 4.5 lb of these chemicals per 100 lb of raw rubber.

Organic compounds not treated in this report include mercaptans that regulate polymerization of monomers to raw rubber, peroxides that initiate such polymerization, fatty acid activators, and various oils used as physical plasticizers and extenders.

Among inorganic substances excluded in this report are elemental sulfur as vulcanizing agent, zinc oxide and other oxide activators, and carbon black, alkaline earth carbonate, silica, and clay reinforcements and fillers.

Rubber-processing chemical output begins slow climb back

Thousands of metric tons	1970 ^a	1982 ^b	1983 ^c	1985
Accelerators, activators & vulcanizers	66.7	32.9	34.9	38.3
Thiazoles	49.4	28.0	28.6	31.6
2,2'-Dithiobis(benzothiazole)	7.5	3.1	4.0	4.4
Dithiocarbonates	4.9	2.3	2.8	2.7
Others ^d	8.4	2.6	3.7	4.0
Antioxidants, antiozonants & stabilizers	88.0	59.9	76.7	85.1
Amino compounds ^e	53.8	39.5	47.9	52.3
p-Phenylenediamines	28.7	24.1	29.5	31.7
Phenolics & phosphites	32.2	20.7	28.8	32.6
Others ^f	32.8	12.1	21.2	23.1
TOTAL	179.2	122.2	132.8	146.5

a All-time high. b Bottom year of recession. c Latest year for which data are available. d Includes aldehyde-amine adducts, guanidines, thiurams, xanthenes, and sulfides. e Includes aldehyde- and isocyanate-amine adducts. f Includes blowing agents, peptizers, and polymerization regulators. Sources: U.S. International Trade Commission, C&EN estimates.

A third effect of rising oil prices has been a reduction in car sizes to improve mileage and lower costs. This "downsizing" also has decreased tire sizes and reduced the total amount of nontire rubber use in cars. The rubber-processing chemical industry may absorb the effects of downsizing by 1990.

The net effect of all these changes of the 1970s is that although the rubber-processing chemical industry has recovered from the one long recession that began for it in 1979, recovery has leveled off at a lower volume. Compounding the problems of a contracted, slow-growth market is the rising tide of imports. Joseph B. Eisenberg, rubber chemicals marketing manager for Uniroyal, estimates that capacity use is only

70% worldwide, compared with 85% in the U.S. This situation stimulates foreign producers to export to this country.

Production and sales of rubber-processing chemicals in the U.S. is a complex mosaic of arrangements. For example, companies like Monsanto produce for the merchant market. Vanderbilt both produces its own chemicals and distributes those of others. Mobay imports most of its chemicals from its parent, Bayer of West Germany, while steadily expanding production in the U.S. Three rubber companies—B. F. Goodrich, Goodyear, and Uniroyal—produce for their own captive needs and sell on the merchant market.

This complex state of affairs makes it hard to ascertain the share of do-

Rubber chemicals:

Three tire firms have more than half of the business . . .

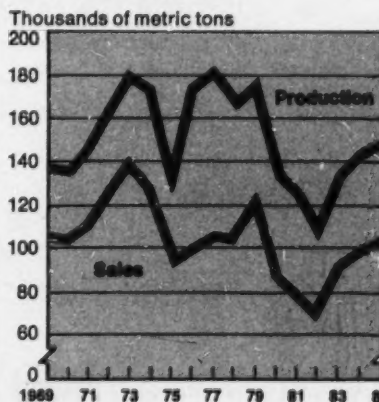
B. F. Goodrich
Goodyear Tire & Rubber
Uniroyal

. . . and 18 other companies share the remainder

Alco Chemical
American Cyanamid
Borg-Warner
Du Pont
Ferro
Fike Chemicals
Hexcel
ICI Americas
Kenrich Petrochemicals
Monsanto
Neville Chemical
Olin
Pennwalt
Phillips Petroleum
Reichhold Chemicals
Signal UOP
Vanderbilt
Westvaco

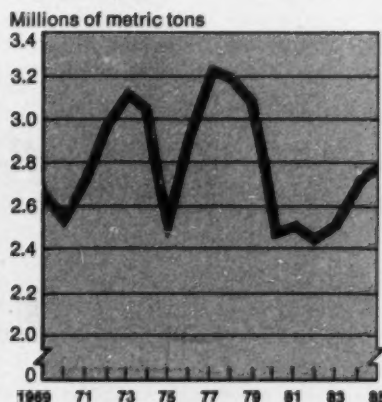
Source: International Trade Commission

Rubber chemicals market has contracted . . .



Sources: International Trade Commission, Rubber Manufacturers Association, C&EN estimates

... matching reduced rubber consumption



mestic production of each company. One person who has studied the U.S. rubber-processing chemical market is Melvin M. Schlechter, an analyst with the consulting firm of Frost & Sullivan, New York City. Working with Schlechter's figures, C&EN has determined that Monsanto is the leader, with 1985 production in the U.S. of about 50,000 metric tons, worth \$170 million. Goodyear Tire & Rubber is second with about 42,000 metric tons, worth \$145 million. Of this amount, Goodyear uses about 27,000 metric tons captively and sells the rest. In third place is Goodrich, which produces about 20,000 metric tons, worth \$68 million. Goodrich uses about 10,000 metric tons captively and sells the rest.

Nearly tied with Goodrich, Uniroyal produces about 19,000 metric tons, worth \$67 million, of which the company uses about 10,000 met-

Glossary of rubber terms

Accelerator. Speeds crosslinking of rubber by sulfur. Example: 2,2'-dithiobis(benzothiazole).

Activator. Renders accelerators more potent. Example: zinc oxide with stearic acid. Alternatively, a secondary accelerator that is an accelerator in its own right but is more often used with others. Examples: thiurams, dithiocarbamates, and guanidines.

Antioxidant. Protects cured rubber products against oxidative degradation in service. Examples: *N*-isopropyl-*N'*-phenyl-*p*-phenylenediamine, which is also an antiozonant, and octylated diphenylamine, which is not. Antioxidants that protect synthetic rubbers from production through processing are called stabilizers.

Antiozonant. Protects cured rubber products against ozone. Examples: waxes, which migrate to the surface to form a physical barrier, and *N,N'*-bis(1,4-dimethylpentyl)-1,4-phenylenediamine, which protects by chemical reaction.

Blooming. Unwanted migration of substances like sulfur to rubber surfaces to produce discoloration.

Bonding agent. Enhances rubber adhesion to fabric or fiber. Example: resorcinol plus hexamethylenediamine.

Cure. Crosslinking of rubber polymer chains to impart elastomeric properties. Also called vulcanization.

Cure time. Time needed for rubber compounds to reach maximum viscosity or modulus at a given temperature; the sum of the scorch time and crosslinking time.

Hard rubber. Rubber cured with 15 to 40% of added sulfur.

Latex. Water emulsion of rubber polymer, used as is for coating or dewatered for making solid parts.

Lubricant. Eases flowing of rubber in molding or extrusion.

Mastication. Preliminary physical and chemical breakdown, usually of natural rubber, in a mill or mixer to reduce viscosity for further processing.

Peptizer. Promotes chemical breakdown of rubber during mastication; also called plasticizer. Example: pentachlorothiophenol.

Pfr. Parts-per-hundred rubber; the number of parts by weight of substance added to 100 parts of rubber.

Plasticizer. A peptizer, an oil, a monomeric ester softener, or an extender. Example: bis(butoxyethoxyethyl) glutarate.

Retarder. Lengthens time before onset of curing. Example: phthalic anhydride. Sulfenamide-type retarders have acquired the separate name of prevulcanization inhibitors. Example: *N*-cyclohexylthiophthalimide.

Reversion. Decrease in rubber modulus or viscosity caused by overworking.

Scorch. Premature curing.

Scorch time. Safety margin of time that a rubber compound can be worked at a given temperature before curing begins.

Soft rubber. Rubber cured with 0.5 to 8% of added sulfur.

Stabilizer. Antioxidant that protects rubber from polymerization through curing. Example: tris(nonylphenyl) phosphite.

Staining. Blue or purple coloration of rubber surfaces due to oxidation of *p*-phenylenediamine-type antioxidants and antiozonants.

Sulfur donor. Organic polysulfide that replaces some elemental sulfur in rubber compounds and promotes curing mostly by monosulfide crosslinks in a process called effective vulcanization. Example: tetramethyldithiuram disulfide.

Vulcanizing agent. Cures rubber by forming crosslinks among polymer chains. Examples: sulfur, organic peroxides, and phenolic resins.

ric tons captively and sells the rest. Mobay Chemical produces some 16,000 metric tons, worth \$57 million. And R. T. Vanderbilt produces about 2000 metric tons, worth \$6 million.

As Schlechter's study for Frost & Sullivan indicates, the sales situation is more complex still. For example, Monsanto sells directly to tire companies, but tends to use Harwick Chemical Co. of Akron and

other distributors to the nontire market. Harwick sells some 11,000 metric tons of Monsanto's chemicals, valued at \$40 million.

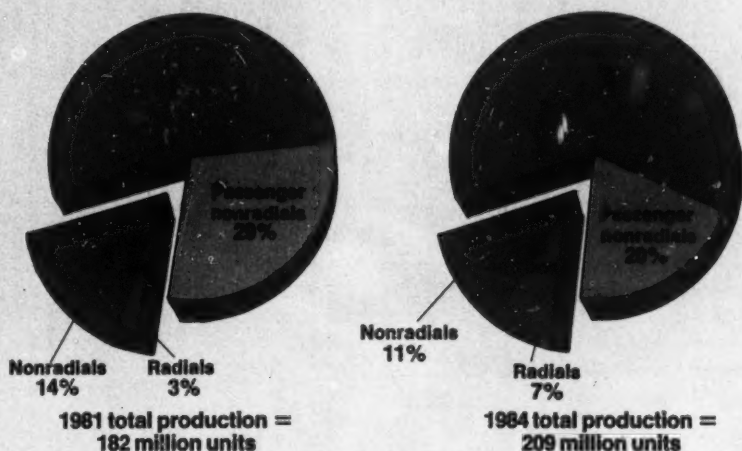
Again, under longstanding agreements with both companies, Vander-

Synthetic rubber output rose in past two years, but remained well below levels of 1970s

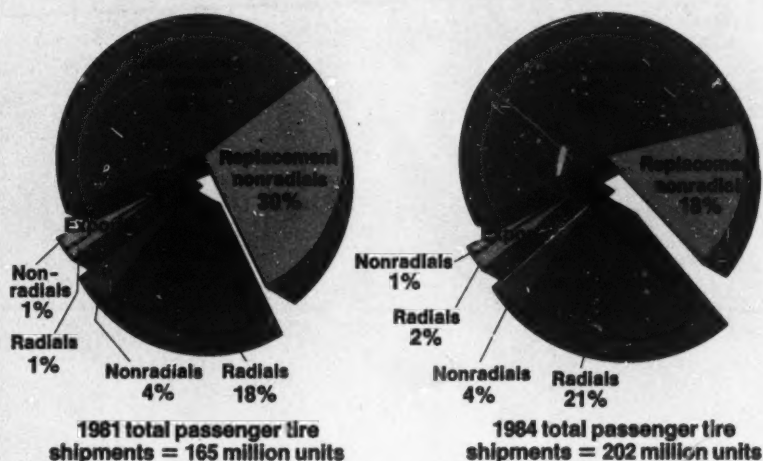
Thousands of metric tons	Production											Annual change	
	1984	1985	1986	1987	1988	1976	1977	1978	1979	1980	1981	1980-84	1974-84
Styrene-butadiene rubber ^a	958	904	876	1032	1074	1378	1396	1396	1333	1175	1468	8%	-4%
Polybutadiene	359	333	298	342	311	397	378	341	352	290	310	8	1
NR ^b	87	55	46	66	63	76	73	70	73	55	68	22	-3
Isoprene-propylene	215	175	123	178	144	175	174	158	130	84	126	23	5
Polyisoprene	130	115	119	143	151	183	181	185	165	144	163	13	-2
Other ^c	365 ^a	353 ^a	379 ^a	261	272	326	292	287	250	188	345	3	0
TOTAL	2995	1939	1838	2922	2915	2534	2473	2416	2369	1840	2496	8%	-2%

^a Excludes high-styrene latex (more than 45% styrene). ^b Includes butyl, polyisoprene, neoprene, and other synthetic elastomers. Excludes polyurethane rubber. ^c Values are partly estimated. Source: Rubber Manufacturers Association.

Radials take bigger share of tire production ...



... and of shipments for use on passenger cars



Source: Rubber Manufacturers Association

bilt sells the accelerator chemicals of Goodyear and the antioxidants and antiozonants of Goodrich. Thus Vanderbilt's total sales of rubber-processing chemicals hover around 7000 metric tons, worth \$30 million. Goodyear sells its own antioxidants and antiozonants. Goodrich markets its accelerators through such other distributors as H. M. Royal of Trenton, N.J., and Akron Chemical Co.

Distributor companies also import rubber-processing chemicals. One such firm is Prochimie of New York City, which represents UCB of Brussels, Belgium, and Manufacture Landaise de Produits Chimiques of Rion-des-Landes, France. It also sells the tetramethylthiuram disulfide

and zinc dimethyldithiocarbamate of UCB Chemicals in Bucks, Ala. A second such firm is Cook Chemical Co. of Akron, which imports a wide line of rubber-processing chemicals from Vulnax International in France.

Schlechter points out in his study that imports of these chemicals are hard to analyze because of a lack of product breakouts by the U.S. Bureau of the Census. He also cites errors of classification, duplication, and nomenclature in import data of the International Trade Commission. Schlechter has reanalyzed ITC data and constructed uniform import tables, which also show which U.S. companies are domestic producers of each compound.

Illustrating the value of such ta-

bles, he says, "For imports of benzothiazole accelerators under dibenzothiazyl disulfide, it would appear that Mobay, Pennwalt, and Cook Chemical are the major importers, because Uniroyal and Monsanto are U.S. producers. R. T. Vanderbilt either buys domestically or imports."

Noting that dibenzothiazyl disulfide is produced by Mobay in West Germany, Pennwalt in Italy, and Vulnax International in France and the U.K., Schlechter says, "Further information on the country of origin would quantify the individual volumes imported by Mobay, Pennwalt, and Cook Chemical in our example, because West Germany, Italy, and France/U.K. would be the respective exporting countries for these companies." The *New York Journal of Commerce* compiles information on amounts and countries of origin of individual chemicals as a service to which people can subscribe.

One of the ways in which U.S. producers plan to compete in the changed market for rubber chemicals is introduction of new products. At Monsanto, for example, commercial development manager Edwin L. Kaiser says the company has introduced hexakis(isopropylthio)melamine as a prevulcanization inhibitor to retard onset of curing. This multifunctional compound is more potent, more compatible with rubber, and works with a wider variety of accelerators than the cyclohexylthiophthalimide Monsanto had previously discovered. The company supplies it mixed with an inert diluent so that compounders can weigh it more accurately.

Also new to Monsanto are sodium and nickel salts of hexamethylene dithiosulfate as what the company calls prevulcanization stabilizers. Such compounds repair shear and thermal damage to rubber polymer chains from overworking by forming new crosslinks. Both chemicals also act as adhesion promoters of rubber to brass-coated steel tire cord, Kaiser notes, in which the nickel salt excels.

These two new compounds also are examples of developments from the worldwide network of Monsanto's research labs that the firm can draw on. Kaiser says the two organo-

Product Report

thiosulfates were invented at the laboratory of Monsanto Europe in Louvain-le-Neuve near Brussels. Though a part of a different Monsanto company, Kaiser says, "the Belgian lab cooperates closely in work for the Akron laboratory. Because the tire and other rubber industries are worldwide industries, we try to maintain Monsanto rubber chemicals as a worldwide entity, working within subsidiary companies."

Another advantage that Monsanto has in competing in the rubber-processing chemicals industry, Kaiser says, is the company's testing instrument business. "Instruments help us to sell chemicals and also to perceive the needs of the industry." In this connection, he says that the Akron laboratory recently has developed a moving die rheometer that may replace the oscillating disk rheometer, which Monsanto also invented and which has become standard in the rubber industry. Another new Monsanto instrument developed at Akron is a tensile strength tester.

Kaiser says that Monsanto's future efforts will focus on improved antiozonants to protect radial tires during their relatively longer lifetime and as radials evolve toward

thinner sidewalls. The company will also work on chemicals with wider processing latitude for automated tire building plants.

At Goodyear, product manager Larry Keller says that the company has introduced the di- β -undecylthiopropionate ester of tetraethylene glycol as a synergist for stabilizers to prolong their antioxidant properties through the vulcanization process. Data so far indicate that the compound works well with phenolic antioxidants in carboxylate latexes. There are also preliminary good results with phenylenediamine-type antioxidants in other rubbers.

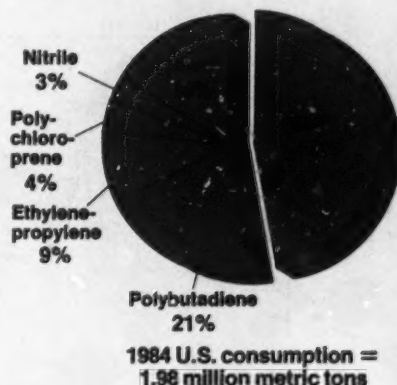
In its quest for new products, Keller says that Goodyear has a strong program in place to research new antioxidants. Product aims include ever increasing potency at lower cost.

At Uniroyal, Robert Mazaika, vice president of the chemicals and polymers division, says that the company has developed a delayed-action accelerator, *N*-dimethylthiocarbamylthio-*N'*-phenylurea. The compound avoids use of morpholine, which has been criticized because of toxicity. Mazaika says the compound contributes good dynamic modulus for enhanced tire rolling resistance. Managers are uncertain whether it will become a general or specialty product, however.

Uniroyal's research efforts concentrate on nonstaining antiozonants. Staining is the appearance of a blue or purple film of reacted additive on rubber surfaces. Mazaika says the company will work on both monomolecular antiozonants and altered rubber polymers as approaches to the problem. He notes that ethylene-propylene-diene monomer (EPDM) rubber resists ozone attack, and one solution could be uniform covulcanization of EPDM and styrene-butadiene rubber (SBR) in sidewalls. Staining would be particularly unsightly on white sidewalls, but Mazaika sees the problem extending to black sidewalls as many tire companies introduce cosmetic black sidewalls to their top-of-the-line products.

Research at Uniroyal also focuses on diffusion rates of monomolecular antiozonants. This is because one

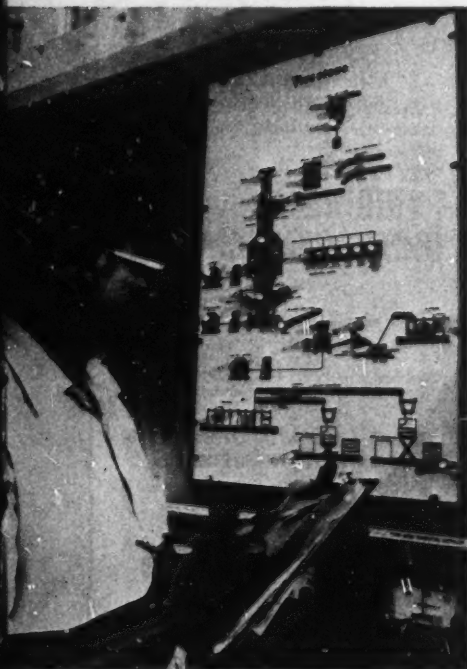
SBR remains most widely used synthetic rubber



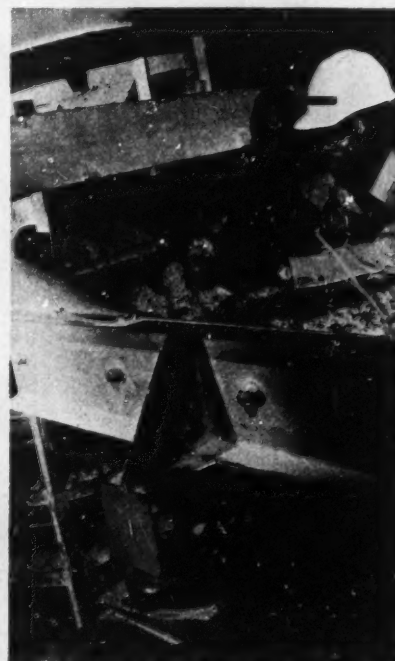
a Styrene-butadiene rubber. b Includes butyl, polyisoprene, and silicone rubbers.
Source: Rubber Manufacturers Association

key to long-term protection of radial tires is continuous, controlled diffusion of additive to the surface.

Researchers at American Cyanamid also are interested in adhesion promoters for radial tires, says marketing manager William Bush. The company recently introduced a resin powder concentrate to meet this need. According to Bush, Cyanamid's competitive stance is "to reduce our product line to those where

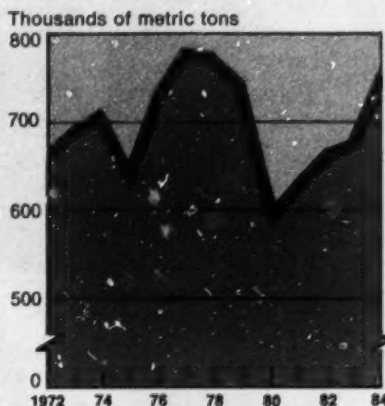


Firestone technician monitors flow of material through mixing operation



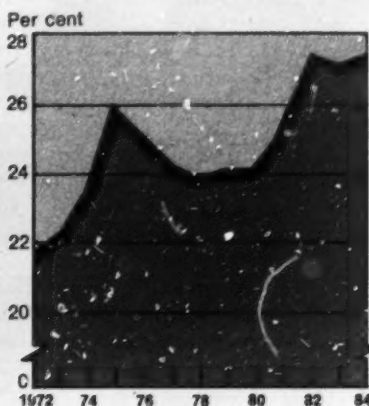
Synthetic rubber being inspected at Goodyear's Houston plant

In U.S., natural rubber use has risen both in volume ...



Source: Rubber Manufacturers Association

...and as a percentage of total rubber consumption



we are basic and to manufacture in-house. Our research is geared to reinforce this idea and to develop new products in those areas."

For this reason, the company withdrew from low-profit benzo-

thiazole and sulfenamide accelerators in 1982, and now concentrates on adhesion promoters, antioxidants, peptizers, guanidines, and vulcanized vegetable oils. "We think this was a correct decision," Bush says.

"The business has been successful since then—very good."

Mobay's recent activities center on U.S. introduction of chemicals already made by Bayer in West Germany and on expansion of U.S. production. A. M. Gabriel, director of the rubber department within Mobay's organic and rubber chemicals division, says that the company has introduced the accelerator morpholinobenzothiazole accelerator here. The firm has also added three phenylenediamine-type antioxidants to production at its plant in Bushy Park, S.C.

Gabriel notes that there is constant interest in the rubber industry in accelerators that delay vulcanization for processing safety but that also give fast cures once vulcanization begins. In this connection, Gabriel says that several customers have asked Mobay to reintroduce *N,N'*-dimethyl-*N,N'*-diphenylthiuram disulfide. This secondary accelerator potentiates the effects of

PRODUCT PROSPECTUS



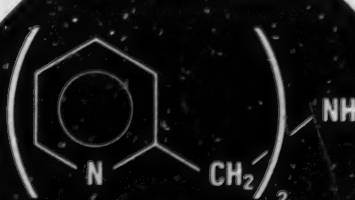
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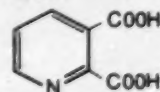


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CIRCLE 45 ON READER SERVICE CARD

Columbus also discovered rubber

Rubber has taken five centuries to reach its current sophisticated level of technology using a host of organic processing chemicals. A true New World product, rubber may first have been noticed by Columbus. The Germans pioneered synthetic rubber in World War I, and synthetic rubber today accounts for two thirds of world-wide use. Following is a chronology of rubber's recorded history.

1492. In what may be the first mention of rubber, Michele de Cuneo returns from Columbus' second voyage and writes that in Hispaniola, "There are also trees that when cut give milk, of which [the Indians] make something like wax, and we have tried it out."

1521. Hernando Cortez sees the Aztecs of Mexico using a gum from trees to waterproof utensils and make balls for games. Spanish colonists also use the gum for waterproofing, but for the next 300 years, it appears in Europe only as balls and other curiosities.

1750. After a 14-year search in South American jungles, engineer François Fresneau finds the rubber tree, *Hevea brasiliensis*. Astronomer Charles de la Condamine reads Fresneau's paper to the French Academy, using the Indian word *caoutchouc* for the gum, derived from *caa* (tears) and *ochu* (wood).

1770. Joseph Priestley writes that the gum makes a good "rubber" to erase pencil marks, but he is probably not the first to use the word.

1810. With the development of solvent processing by English inventor Thomas Hancock, manufacture of rubber articles begins in England. Products eventually include the raincoat of Charles Macintosh (1823) and water-

proof shoes. Hancock also builds a machine that renders rubber more malleable, thus inventing mastication. Still, rubber goods are inferior, becoming sticky in summer and brittle in winter.

1839. Charles Goodyear accidentally finds that heat cures a compound of rubber, sulfur, and lead carbonate to a hard, resilient, infusible solid. Hancock discovers the process independently and coins the term vulcanization. Goodyear gets a patent, U.S. 3633, June 15, 1844.

1878. Coffee planter Henry Wickham smuggles 70,000 Hevea nuts out of Brazil, which until now has had a monopoly on world rubber production. The British send 3000 seedlings grown in Kew Gardens, London, to start plantations in Ceylon, Malaya, and Singapore. By 1900, plantings reach 4000 acres in those lands.

1888. Veterinarian John Boyd Dunlop makes pneumatic tires for bicycles. Extension of this idea to automobile tires will make the fortunes of both the rubber and auto industries.

1906. Chemist George Oensager at Diamond Rubber Co., Akron, discovers that aniline accelerates vulcanization. Though abandoned as too toxic, this compound becomes the first in a long line of organic accelerators commercialized in coming decades.

1910. Recent invention of the automobile stimulates production of 94,000 tons per year of rubber as prices skyrocket to \$3.12 per lb. Chemistry professor Carl Dietrich Harries at the University of Kiel, Germany, discovers that sodium catalyzes polymerization of 2,3-dimethylbutadiene to a synthetic "methyl rubber."

1918. By the end of World War I, Germany has produced a total of 2350 tons of methyl rubber.

1927. German chemists develop Buna S (butadiene-natrium-styren) rubber, spearheaded by work of chemistry professor Karl Ziegler at Heidelberg University. German patents also appear on rubbers made by reactions of di- and trichloroalkanes with alkali polysulfides.

1931. Du Pont announces neoprene, a synthetic rubber made from chloroprene, whose commercial synthesis has been developed by Wallace H. Carothers.

1942. Cut off from supplies of natural rubber, the U.S. government orders the planting of 75,000 acres of the guayule shrub. After World War II, work on guayule rubber will be abandoned. U.S. industry gears up to produce various synthetic rubbers, which will reach 700,000 tons in 1945.

1955. Studies of tire cracking in the smog-laden atmosphere of Los Angeles implicate ozone as the cause, which leads to use of organic antioxidants in rubber compounds.

1973. U.S. consumption of natural rubber has bottomed out at 22% of all rubber used here. But now the Arab oil embargo and steep rises in oil prices set off a series of price increases in feedstocks that throughout the decade tilt the balance against synthetic rubber.

1985. World rubber production is 13.7 million tons this year, of which 32% is natural. The U.S. consumes 2.8 million tons, 28% of it natural. To fabricate this amount of rubber, the U.S. uses 150,000 tons of organic rubber-processing chemicals.

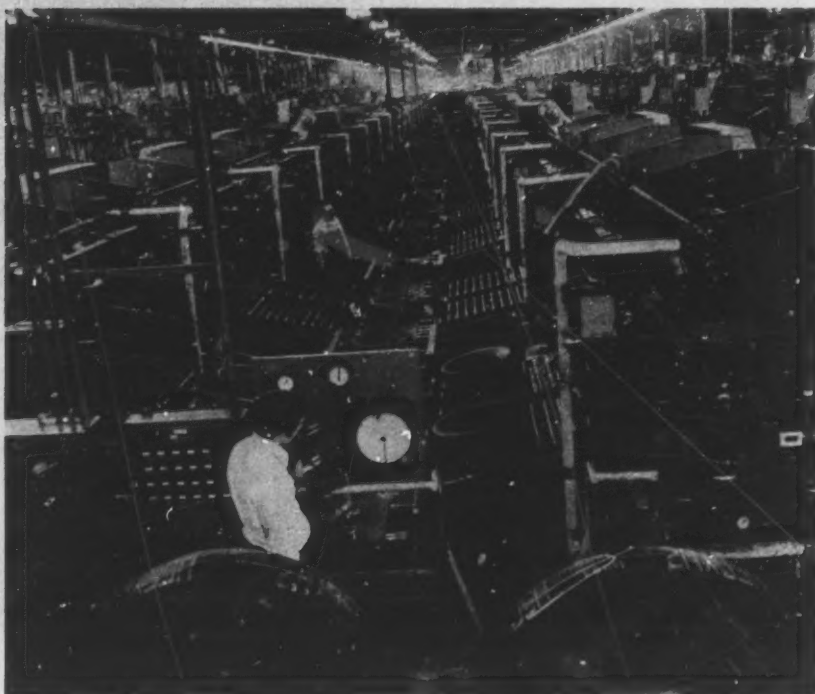
other accelerators and yields safe, fast cures at relatively low temperatures.

The contribution of C. P. Hall Co. to the industry is a line of ester physical plasticizers. To rubber compounds, plasticizers are of two kinds. One is a class called peptizers, which reduce viscosity of natural rubber by chemical change. The other class consists of oil and ester physical softeners and extenders. New

products at C. P. Hall include two glutarate polyesters, a trinonyl trimellitate, and a trinonyl glutarate. All of these plasticizers are designed to promote good low-temperature properties in nitrile, polychloroprene and chlorosulfonated polyethylene rubbers. The polyesters resist extraction, volatilization during processing, and weathering, and enhance plasticizing efficiency. Company spokesmen say the branched

nonyl monomolecular esters are more economical, compatible, and efficient than competing glutarates and trimellitates, and yield better low-temperature properties.

Pennwalt's Lucidol division in Buffalo, N.Y., has intensified its marketing of peroxide vulcanizing agents to the rubber industry. Peroxides are more expensive than the elemental sulfur and not widely used. They are also incompatible



Radial tires pour from curing presses at Goodyear's Topeka, Kan., plant

with most antiozonants and phenolic and phenylenediamine-type antioxidants. This is because amines and phenols trap free radicals. Nevertheless, peroxides yield rubber goods that have superior heat aging, resilience, color, and odor, and they crosslink saturated as well as unsaturated polymers to elastomers. The most important such peroxide for rubber vulcanization probably is dicumyl peroxide.

One new technology where peroxides find use is covulcanization. For example, Lucidol spokesmen say that a blend of 75% polyethylene and 25% EPDM can be cured to homogeneous wire insulation that has corona resistance, cure rates, hot modulus, and flexibility that are superior to crosslinked polyethylene. Peroxide curing of the same resin blend also produces heat-shrinkable tubing, gaskets, and belts.

Schiechter of Frost & Sullivan notes that some firms serve the rubber industry that make no effort to

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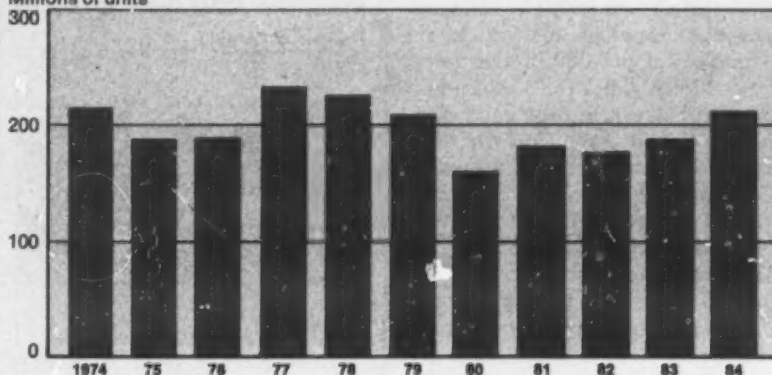
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Tire production recovers from early 1980s slump

Millions of units*

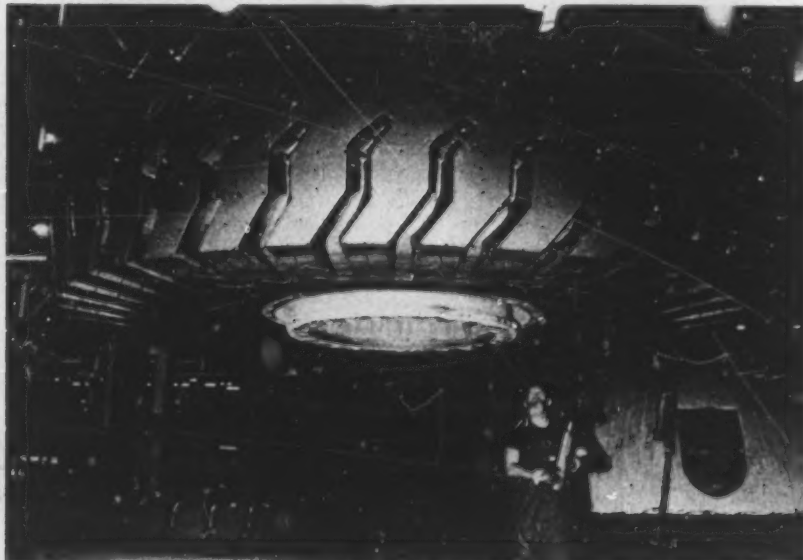


* Excludes mobile home tires since 1977 and motorcycle tires since 1978.
Source: Rubber Manufacturers Association

field complete lines of processing chemicals. He cites Borg-Warner, which makes about 20 organophosphate antioxidants and sells some of them to rubber compounders in addition to its major sales to the plastics industry. Du Pont and Reichhold view their participation in the rubber industry with styrenated phenol antioxidants as adjuncts to their roles in the plastics industry, Schlechter says. And Signal UOP's phenylenediamines are used mostly as gasoline additives.

In addition to marketing new products, producers of rubber-processing chemicals improve their competitive stances by production in many parts of the world. As al-

ready noted, Mobay in the U.S. and Bayer in Europe have such production networks. Monsanto produces at 13 plants in nine countries. And Uniroyal has nine plants in seven countries. For such major producers, location of plants in many countries is part of their view of rubber-processing chemicals as a worldwide industry. For such firms as Pennwalt—whose organic chemicals division has shifted much of its accelerator production to Termoli, Italy—or Vanderbilt, which has a new joint venture, Artivi, near Mexico City, such moves may reflect a desire to lower production costs to compete better in the U.S. as well as elsewhere.



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Product Report



Specialty rubber applications include insulation on copper tubing for air conditioners (above), large-diameter hose (left) in oil drilling

ler, American Motors, Renault, Nissan, and Volkswagen), its tire industry (Goodyear, Uniroyal, and joint ventures of Goodrich and General Tire & Rubber), a mostly self-sufficient synthetic rubber industry, and the high priority the Mexican government has given to rubber. Predicasts is aware of the current social and economic ills of the country and the worldwide overcapacity of oil production, but remains cautiously optimistic over the long term.

Predicasts ascribes Brazil's strength to a reliance on motor vehicles for transportation in a country poor in railroads, coastal shipping, and air transport. The nontire rubber industry also is healthy, because of Brazil's industrial and consumer goods expansions. Also, on the plus side, Brazil remains an important producer of natural rubber, has built up a synthetic rubber industry, has a large, self-sufficient tire industry, and has a focus on exports and trade barriers to imports. On the debit side, the country is beset by economic problems, has no competitive edge in synthetic rubber production, and is plagued by tree diseases in its efforts to expand rubber plantations. □

sumption, and high population growth rates in those regions, to achieve relatively large increases in rubber consumption. Again, the high proportion of growth in manufacturing to overall economic growth in developing countries leads Predicasts analysts to forecast a greater-than-usual growth in nontire rubber goods for industrial and consumer uses.

The Cleveland firm's optimistic outlook on Mexico is based on its oil and gas resources, its auto industry (General Motors, Ford, Chrys-

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APRIL 22, 1985

CHEMICAL & ENGINEERING

NEWS

FUEL ETHANOL

Battle shaping up
over imports
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■ Function of trypsin selectively altered by UCSF researchers. Page 4

■ OSHA says existing guidelines to protect workers from hazard are adequate to cover those in biotechnology industry. Page 5

■ Uniroyal's fate still undecided in midst of proxy fight. Page 5

■ Union Carbide gets okay to restart institute plant, agrees to contribute \$5 million to aid Bhopal victims. Page 5

■ First-quarter earnings for U.S. chemical companies were generally on the down side. Page 5

Business

Slow growth in demand for major mineral acids means a supply/demand balance for phosphoric, overcapacity for sulfuric. Page 18

Government

GAO report finds illegal disposal of hazardous wastes difficult to deter; Defense report on Soviet military power says little on chemical weapons, points up U.S.S.R. missile defense. Page 22

Science

Jacqueline K. Barton of Columbia University wins NSF award for use of inorganic chemistry to study biological molecules. Page 25

Technology

Phillips Petroleum's new process to make 3-methyl-1-butene uses fairly simple equipment; advances in ceramic research let Sandia researchers devise high voltage-regulating varistors. Page 27

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Membership rose to record 134,449 in 1984; society program won Presidential citation for private sector initiatives. Page 33

ACS News

University of Illinois, Urbana-Champaign, topped list of 1984 B.S. chemistry graduates with 139; ACS Committee on Professional Training's 1984 report shows rise in M.S.s and Ph.D.s. Page 57

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News Focus

Fuel-grade ethanol from Brazil is subject of antidumping and countervailing duty suits; issue challenges U.S. trade policy and management of international debt. Page 9

Battle Rages over Imports of Fuel Ethanol

In addition to antidumping and countervailing duty suits against Brazil, both the Caribbean Basin Initiative and tariff loopholes figure prominently in the struggle to cut off large-volume imports

Earl V. Anderson, C&EN New York

Fuel-grade ethanol is fueling more than cars, trucks, and tractors in the U.S. It also is fueling a high-octane battle over imports.

The latest beachhead was established earlier this month when the five commissioners of the International Trade Commission voted unanimously that there is a "reasonable indication" that imports of fuel ethanol from Brazil are threatening to cause material injury to the U.S. fuel ethanol industry.

The vote came after a consortium of domestic producers filed an antidumping and a countervailing duty petition against Brazilian fuel ethanol imports. The U.S. producers claim they are being hurt by Brazilian ethanol that is heavily subsidized by the Brazilian government and that is being sold in U.S. markets at less than fair value.

The ITC action doesn't end the battle over fuel ethanol imports from Brazil. It comes after only a preliminary hearing and means that the investigation will continue. ITC will look more closely at the question of injury. Meanwhile, the Department of Commerce's International Trade Administration (ITA) will check out the dumping and subsidies issues. Had ITC found no injury or threat of it, the antidumping and countervailing duty cases would have been shelved.

However, with ITC's affirmative vote, the battle will continue. For domestic producers and their farm bloc allies, it is the major assault on import competition. It is, however, only one assault.

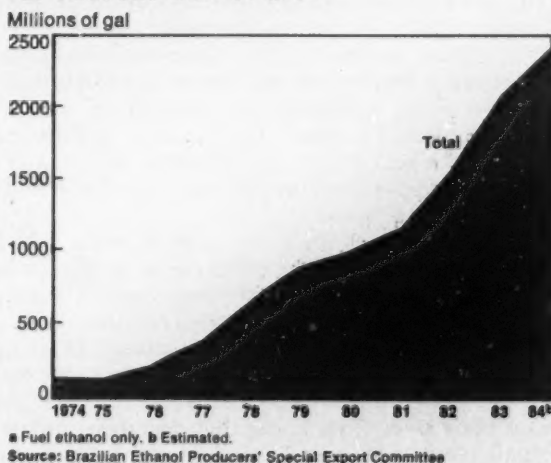
Potentially, large volumes of duty-free fuel ethanol from the Caribbean area also pose a threat to domestic producers. They are maneuvering to meet this threat by petitioning the Customs Bureau for changes in the rules that make duty-free imports from the Caribbean possible. The outcome of this fight could have significant repercussions for one of the Reagan Administration's pet foreign economic aid programs, the Caribbean Basin Initiative.

In addition, the domestic industry wants to close what it says are loopholes in the tariff structure. They claim that imported fuel ethanol is slipping into the country through these loopholes without paying the 60 cent-per-gal duty imposed to protect the fledgling domestic industry. Legislation already has been introduced to plug these loopholes.

The economic stakes are high in this three-front battle—for U.S. producers, for U.S. farmers, and for the U.S. motorist and taxpayer. They are high, too, for those countries, primarily economically strapped developing nations, that are counting on the U.S. fuel ethanol market as a source of much-needed foreign exchange.

Nobody really knows yet just how high those stakes are. The U.S. fuel ethanol market has grown rapidly from virtually nothing in 1978 to a half-billion gal-

Brazil's ethanol production far exceeds that of U.S.



U.S. producers, farmers accuse Brazil of dumping

The 13 U.S. producers of fuel ethanol and the one farm bureau that filed the antidumping and countervailing duty petitions against Brazilian fuel ethanol imports represent about 69% of domestic production capacity. They are:

Alcon Industries	Midwest Solvents Co.
Archer Daniels Midland	New Energy Co. of Indiana
Bio-Chemical Energy	Ohio Farm Bureau
Byron Elevator Co.	Development Corp.
Graf Feed & Fuel	Pekin Energy Co.
Alcohol	Southern Ethanol
Grudem Bros. Co.	South Point Ethanol
KV Alternatives	A. E. Staley Mfg. Co.

lions last year. Now, two recent Environmental Protection Agency decisions figure to raise the ante. One is EPA's long-expected regulations on phasing out use of lead additives in gasoline. The other is the conditional waiver granted to Du Pont for blends of unleaded gasoline and alcohols. The waiver allows up to 5% methanol and up to 2.5% cosolvents. For fuel ethanol producers, the kick is that, for the first time, ethanol is specified as a possible cosolvent alcohol with methanol.

Market analysts haven't put firm numbers on the potential for fuel ethanol as a result of EPA's decisions. Many consultants are busy trying to do just that. But all agree that the two decisions will increase fuel ethanol demand dramatically.

In addition to the economic issues, all sorts of government policies are involved. It was the government that established the tax subsidies and loan guarantees by which the domestic fuel ethanol industry was created in the first place. Those initiatives came in the late 1970s when the government wanted to develop alternative domestic fuel sources to replace then-scarce and unstable foreign oil supplies.

The government also created the Caribbean Basin Initiative—designed to provide an economic crutch for Caribbean nations and help keep them out of the socialist camp. Meanwhile, the Administration is trying to keep a lid on protectionism. With Brazil, this is a particularly touchy issue. The country already has been hit with several U.S. protectionist moves, and it must export to pay back the billions of dollars it owes, much of it to U.S. banks.

As a result, trade policy and even diplomacy have crept into the picture. The State Department, for instance, has its own study under way on the implications of Brazilian and Caribbean fuel ethanol.

As the battle over fuel ethanol imports heats up, U.S. producers and the farmers that supply them with their raw material (primarily corn) feel that the gods are on their side. They know that Congress initiated the policies that launched the domestic fuel ethanol industry. Hard-pressed farmers are certain that Con-

gress doesn't want to make a bad situation worse for them. And farmers need the markets that fuel ethanol provides.

On the other hand, foreign ethanol suppliers and a handful of supporters in the U.S. believe that they have logic on their side. They contend that if the fuel ethanol market really takes off as expected, U.S. producers won't be able to meet the demand. And they claim that they can produce fuel ethanol more economically, primarily from sugar, than U.S. producers can from corn. Without imports, they say, U.S. taxpayers will have to continue subsidizing a domestic industry that is uncompetitive without the subsidies.

The heavy artillery in the war over fuel ethanol imports is the antidumping and countervailing duty petitions aimed at Brazil. Because of the sheer volumes involved, this is not surprising.

Both petitions were filed by the ad hoc Committee of Domestic Fuel Ethanol Producers. The committee is a group of 13 ethanol-producing companies and the Ohio Farm Bureau Development Corp. Together, they represent 69% of U.S. fuel ethanol capacity.

Despite the number of names on the petition, most observers familiar with the industry believe that Archer Daniels Midland (ADM) is the key player. With about 300 million gal of fuel ethanol capacity, ADM is by far the largest domestic producer. And, according to one outside estimate, ADM controls about 50% of the domestic market. In fact, in responding to the petitions, some Brazilian spokesmen argue that it is ADM, not Brazilian imports, that is the culprit in the U.S. fuel ethanol market.

ADM, however, is not the issue in the two petitions. In the antidumping case, the domestic committee charges that Brazilian fuel ethanol is being sold in the U.S. at less than fair value; that is, it's being dumped. The countervailing duty petition claims that the Brazilian government subsidizes producers and exporters of fuel ethanol. Accordingly, U.S. producers want both antidumping penalties and countervailing duties imposed retroactively on Brazilian fuel ethanol imports.

Both ITA and ITC will determine the outcome of the petitions. By law, ITA determines whether dumping and subsidies actually exist. ITC tackles the injury question.

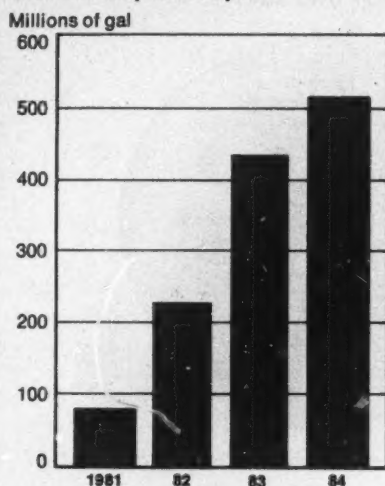
For a country such as Brazil, which is a member of the General Agreement on Tariffs & Trade (GATT), there can be no antidumping or subsidy penalties unless a domestic industry is injured or threatened with injury, or unless imports prevent an industry from being established.

ITC already has ruled that there is a "reasonable indication" that the domestic fuel ethanol industry is "threatened" with injury by Brazilian imports. But this is a preliminary determination based on a preliminary hearing used to screen out frivolous cases. If ITA rules that Brazilian imports are either dumped or subsidized, then ITC will have to make a final decision on injury.

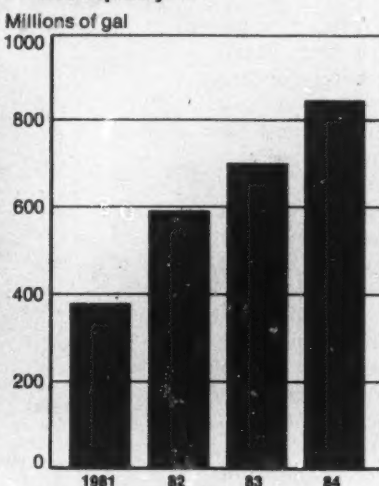
Normally, if injury is found in preliminary hearings, it's also found in the final rulings. But not al-

Why U.S. producers frown on imports of fuel ethanol from Brazil

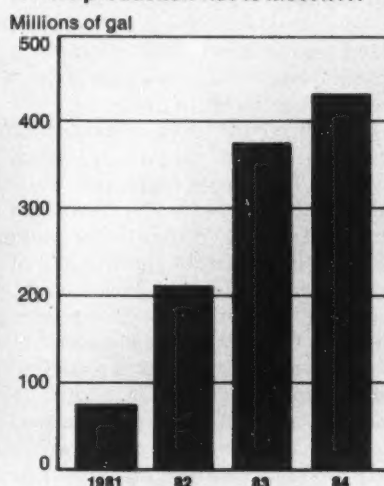
U.S. consumption is up ...



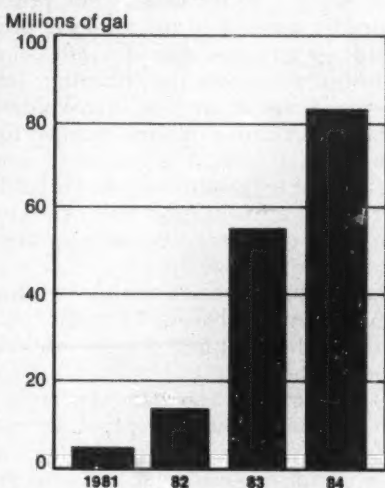
... and capacity ...



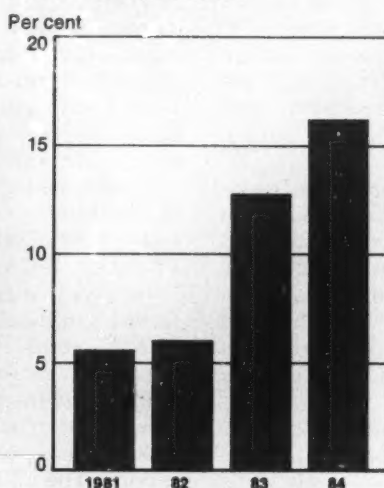
... and production rise to meet it ...



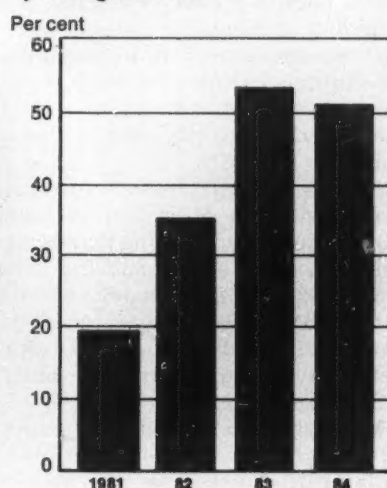
... but strong imports from Brazil ...



... increase Brazil's share of U.S. market ...



... and keep U.S. plant operating rates low



Source: Antidumping petition submitted by ad hoc Committee of Domestic Fuel Ethanol Producers

ways. "There's nothing automatic about it," says one ITC official.

According to the ad hoc committee, the U.S. fuel ethanol industry is being more than injured; it is "facing critical circumstances as a result of unfairly traded Brazilian imports." It says this even though the U.S. market for fuel ethanol, which didn't exist six years ago, has mushroomed to 513 million gal last year.

Now that the lead phasedown regulations are in place and the Du Pont waiver granted, demand for fuel ethanol is certain to become much higher. Estimates vary, but some go as high as 1 billion gal per year by 1990.

The domestic industry has grown along with the market. In 1978, production was a barely discernible

10 million gal. It grew to 75 million gal in 1981 and continued upward to 430 million gal last year. Primarily with the help of government loan guarantees, capacity has been built up to 840 million gal annually, according to the ad hoc committee.

Despite this impressive growth, the ad hoc committee says that the domestic industry is in trouble. Industry operating rates are low—an average 52% of capacity in 1984. Three out of five fuel ethanol plants are shut down. Only 58 of the 145 plants with capacities in excess of 500,000 gal per year were still operating at the end of last year.

The committee claims that domestic producers have lost sales and market share. Many companies are losing money, forcing them to shut down their plants.

Future growth of the industry is jeopardized because investors are becoming increasingly reluctant to commit capital.

All of this, say the petitioners, is the result of subsidized and dumped fuel ethanol imports from Brazil. Brazilian material, they complain, has been flooding the country in record amounts.

On the record, they are right. Official Census figures confirm the growth of Brazilian fuel ethanol imports. They have increased 20-fold, from 4 million gal in 1981 to a hefty 83 million gal last year. Even at this level, Brazilian imports of fuel ethanol have been able to almost triple their share of the U.S. market, from 5.5% in 1981 to 16.2% last year.

But the committee says that the 83 million gal of Brazilian imports last year doesn't tell the whole story. The figure is low, claims the committee. It has "strong reason" to believe that an additional 50 million gal of Brazilian ethanol earmarked for fuel use actually came into the country as industrial-grade ethanol. There is only a 3% ad valorem duty on industrial ethanol imports. But importers of fuel-grade ethanol must pay that 3% plus the special 60 cent-per-gal tariff designed to offset the 60-cent federal excise tax subsidy that domestic producers receive. If Brazilian ethanol imported as industrial material were later diverted to fuel use, importers avoided paying about \$25 million in additional duties, at least temporarily, says the committee. It amounts to an interest-free loan from the government until, and if, the additional duty is paid.

John G. Reed Jr., ADM's international vice president, quotes an official of Petrobras, the Brazilian state oil company, as saying that Brazil actually exported 191 million gal of fuel and industrial ethanol to the U.S. last year. Census figures show only 137 million as the 1984 Brazilian import total. "Although the exact figure is in doubt, the effect of Brazilian imports is clear," says Reed, referring to Brazil's huge gain in U.S. market share.

Meanwhile, U.S. producers suspect that an inventory of at least 75 million gal of Brazilian ethanol was built up in the U.S. by the end of last year. This amount, they point out, exceeds total Brazilian fuel ethanol exports to the U.S. between 1981 and 1983.

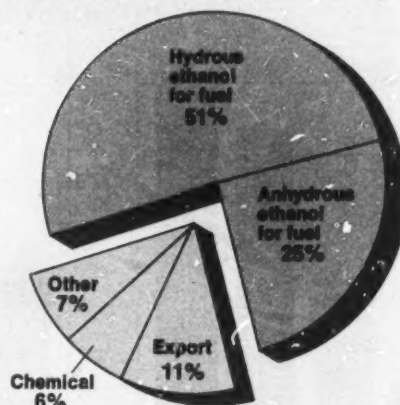
The committee argues that this buildup of Brazilian fuel ethanol in the U.S. was no accident. It was deliberate, it says. The committee claims that Brazil produced much more fuel ethanol than it consumed last year, leaving the country with a surplus of 528 million gal. Despite this, the government has plans to expand capacity and output of fuel ethanol. Since its heralded Proalcool (national fuel ethanol) program can't soak up this output, the pressure is on to export.

According to the petitioners, Brazil has targeted the U.S. as its principal export market. It wants to export 500 million gal of fuel ethanol to the U.S. this year. That about equals last year's total U.S. consumption.

Brazil's export potential to the U.S. could reach 1.5 billion gal by 1990. Thus, says the committee, "the flood of Brazilian imports has not even crested."

To market its surplus production in the U.S., Brazil

Most of Brazil's ethanol production goes into fuel



1984 consumption = 2 billion gal

Source: Brazilian Ethanol Producers' Special Export Committee

is charged with offering fuel ethanol at cut prices only in markets already developed by domestic producers. Lauren L. Hill, general manager of South Point Ethanol, South Point, Ohio, notes that Brazilian imports always seem to be aimed at existing, high-volume customers in states where those imports qualify for state tax incentives. "I have seen no evidence of new customers being converted to [gasoline-ethanol] blends by marketers of Brazilian ethanol, says Hill. And, he adds, "I have seen them offer large volumes of low-priced ethanol to my existing customers."

He says that after building up sales volume in Ohio from 1.1 million gal in January 1984 to 2.3 million gal in May, South Point's sales declined sharply back to 1.2 million gal in September.

Domestic interests claim that Brazilian imports are able to undercut the market because their fuel ethanol industry is heavily subsidized, from production to exports. The ad hoc committee estimates that importers of Brazilian material are selling fuel ethanol in the U.S. for only 39% of its foreign market value. That's equivalent to a dumping margin of 154%.

South Point's Hill says that his company was forced to cut selling prices 16 cents per gal between January and September last year. But the real telling evidence on prices is contained in the confidential version of the petitions.

Given the corporate relationship between Brazilian exporters and importers, the ad hoc committee charges that importers of Brazilian fuel ethanol must have known about the unfair trading practices. Most Brazilian ethanol is exported by Petrobras Comercio Internacional (Interbras), a subsidiary of Petrobras. And most of the imports come through Interior Trade Inc., of New York City, which is an Interbras subsidiary.

In presenting all of these arguments to ITC and ITA, producers in the U.S. also paint themselves as an emerging industry that is the creation of government

policy. Indeed, it has been nurtured by a wide variety of federal and state economic incentive programs. Among them are investment tax credits, loan guarantees, and federal and state excise and sales tax exemptions for ethanol-containing fuel. "These important expressions of public policy are being thwarted" by massive Brazilian ethanol fuel imports, says the ad hoc committee.

The Brazilians, of course, don't see things quite the same way. They claim that ADM, which "engineered" the petitions against Brazilian fuel ethanol imports to continue its dominance over the U.S. market, is really the villain, not themselves. Rather than hurting the U.S. industry, the Brazilians say that they have helped it in the past and will be even more essential to it in the future.

The basis for their argument is that U.S. producers haven't been able to meet the demand that has developed already and they won't be able to in the future, especially if the market responds to lead additive phaseout as expected. Market growth will depend on adequate and assured supplies of fuel ethanol. U.S. producers, say the Brazilians, haven't been able to offer that, and Brazilian imports have had to take up the slack. Without those imports, some fuel ethanol customers would have switched to other products, they say.

Roger A. Clark, an attorney for Internor, notes that last year U.S. fuel ethanol production fell 137 million gal short of reported U.S. sales. That was not because domestic capacity was underutilized, he argues. "The domestic industry would not and could not have pro-

duced any more if there had been no imports last year," Clark says.

The reason, he adds, is that there wasn't enough capacity to produce more. When the domestic producers say that they operated at 52% of capacity, they base it on a capacity of 840 million gal per year. Internor says that figure is "way overstated." The Brazilians think that actual capacity was more like 625 million gal. And, after discounting plants that were shut down for a variety of reasons or didn't come on stream until late in the year, effective capacity was even less. The 430 million gal that U.S. companies cranked out was just about as high as they could go, say the Brazilians. Without their imports, there would have been a shortage in the U.S. fuel ethanol market that would have undermined its market acceptance.

Comparing U.S. fuel ethanol production to Brazil's is like comparing Tiny Tim to King Kong. U.S. output last year was 430 million gal. In Brazil it was a staggering 2.5 billion gal. But Brazilian spokesmen insist that they have not flooded the market. Nor do they intend to. In fact, they insist, they are unable to.

Marco Marangoni, export section chief of Petrobras' alcohol marketing division, says that Brazil's Proalcool program was developed to satisfy the Brazilian market and to help make the country self-sufficient in energy. Exports, he says, are secondary.

Statistics that show Brazil's fuel ethanol exports to the U.S. jumping from 4 million gal in 1981 to 83 million in 1984 are accurate. But they don't tell the whole story and can be taken out of context.

In 1980, those exports were 37 million gal. They fell to 4 million gal in 1981 and 13 million gal in 1982, because Brazil either did not have excess ethanol to export or because it could not compete effectively in the U.S. market. In 1983, exports to the U.S. grew to 53 million gal before hitting the 83 million gal last year.

Marangoni says that the surge in exports to the U.S. came late last year for a very good reason. Importers of Brazilian ethanol were trying to beat the 10-cent tariff increase (to 60 cents per gal) that became effective Jan. 1, 1985. Much of these late-arrival imports was put in storage and the inventories are "being sold off in the ordinary course of business."

What's more, Petrobras won't export ethanol to the U.S. this year "in any meaningful amount" until July or August, after the next sugar harvest. Marangoni expects that 70 million gal could be available for export to the U.S. from the 1985-86 crop year surplus. But he wonders if it will be possible to market any Brazilian ethanol in the U.S. in the face of the 60-cent tariff.

Lamartine Navarro Jr. agrees that Brazil isn't in a position to jeopardize U.S. fuel ethanol producers. Navarro, a member of the recently formed Brazilian Ethanol Producers' Special Export Committee and a director of Sopral (an association of Brazilian distillers), says that Brazil is much more concerned with its domestic market than with exports. That market is growing at the rate of 500 million gal per year as ever-more cars designed to run on neat ethanol roll



Sugarcane could yield 70 million gal of fuel ethanol for export from Brazil's 1985-86 crop year surplus

off Brazilian assembly lines. That annual increase, Navarro points out, amounts to building up an entire industry the size of the U.S. fuel ethanol industry every year.

He warns that unless Brazil makes the necessary plans and investments to supply an export market, the amount of Brazilian ethanol available to meet the anticipated U.S. shortfall will decline. In a very few years, it will disappear. Brazil will not plan or invest until U.S. policy makes it clear that there is a role for Brazilian ethanol to play, he says.

Navarro, like many of his countrymen, thinks that Brazil is being punished because it has a significant cost advantage over U.S. producers of fuel ethanol. He notes that, in the U.S., federal and state tax exemptions amount to a subsidy of at least \$1.00 per gal. "That's more than the FOB [free on board] price of Brazilian ethanol," says Navarro.

He concedes that Brazil's Proalcool program was established with government help, just as it was in the U.S. That is, it was subsidized. But the sector now produces ethanol without subsidies. Meanwhile, export subsidies have declined and are scheduled to disappear completely by the end of this month.

U.S. importers of Brazilian ethanol also dismiss the argument that Brazilian product caused the sharp drop in U.S. fuel ethanol prices last year. According to Dean Walcutt, president of Certified Oil, Columbus, Ohio, the real cause was declining gasoline prices coupled with a large and sudden increase in fuel ethanol capacity in the U.S. Midwest.

Certified Oil is the largest private-brand, independent gasoline marketer in Ohio and uses ethanol in

almost all of its product. Walcutt buys Brazilian ethanol, but he also buys U.S. product from four companies listed on the antidumping and countervailing duty petitions.

After spelling out the chronology of fuel ethanol and gasoline price cuts in Ohio and other Midwest states for ITC, Walcutt says that Brazilian ethanol imports were not the instigator. In October, New Energy Co. of Indiana opened its plant at South Bend. ADM reopened its Peoria unit. This new capacity, coupled with declining gasoline prices, triggered the price cuts in fuel ethanol, says Walcutt. And, he adds, it was ADM, not the Brazilians, that led the price cutting. The Brazilians "are not the predator," Walcutt says. "They are the predatee." He notes, too, that fuel ethanol prices have gone back up since gasoline prices also have risen.

Brazilian spokesmen charge that the whole fuel ethanol issue raises serious questions about U.S. trade policy and the management of international debt. Navarro says that U.S. protectionism threatens to harm U.S.-Brazilian trade relations. He indicates that the special 60-cent tariff on imported fuel ethanol could lead to trouble for the U.S. among GATT members. And he wonders if the U.S. really wants debtor countries such as Brazil to earn the foreign exchange they need to meet their debt obligations.

Arguments such as these may put pressure on the Reagan Administration, but they shouldn't really matter in antidumping and countervailing duty cases. What does matter are prices, subsidies, and injury.

The injury criteria have been eased to make it easier for domestic industry to prove it. Now imports need not be the only cause of injury, or the principal cause, or the major cause. They don't even have to be a substantial cause. ITC only has to find that imports contribute to injury or the threat of it, as it did in its preliminary ruling.

ITC and ITA, however, aren't the only theater of operations in the war over fuel ethanol imports. Customs officials are considering a proposal that could have significant implications for the Caribbean Basin Initiative program.

This petition, filed by the National Corn Growers Association and four others who were also petitioners in the Brazilian cases, seeks to reverse a Customs ruling that allows ethanol that is upgraded to fuel grade in Caribbean countries to enter the U.S. duty free.

Tropicana International, a subsidiary of Tropicana Petroleum, Brea, Calif., recently opened a 20 million gal plant in Jamaica to upgrade "wet" ethanol to "dry," fuel-grade material. Similar projects are planned for Antigua and the Virgin Islands.

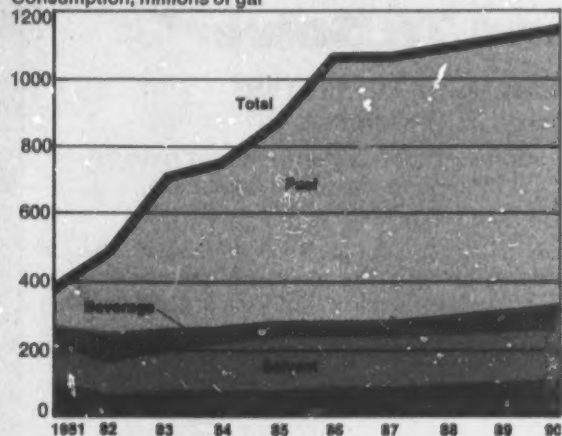
U.S. producers claim ethanol that is merely dried in the Caribbean units doesn't deserve duty-free treatment in the U.S. and the maneuver is just an attempt to dodge the 60-cent tariff. The CBI program was initiated to help economically depressed Caribbean countries. It allows imports, with certain exceptions, from eligible countries to come into the U.S. duty free. To prevent abuses, CBI rules say that at least 35%



Cedar Rapids, Iowa, corn wet milling complex of Archer Daniels Midland, by far the largest producer of fuel ethanol in the U.S.

Ethanol: fuel is its future in U.S.

Consumption, millions of gal



Source: ChemSystems, Oppenheimer & Co.

of the product's value must be added in the Caribbean country. And these rules stipulate that the product must be "a new or different article of commerce" (compared to the material from which it is made).

According to U.S. producers, Tropicana's plant in Jamaica and similar planned projects in the Caribbean are essentially "drying operations"—simple distillation units that take wet ethanol from Spain, Brazil, and other countries and remove the water to increase the "proof" of the ethanol. Tropicana insists that its distillation operation is much more sophisticated than that.

Customs has ruled that such ethanol from CBI countries is eligible for duty-free treatment. The domestic petitioners disagree and want the ruling changed. The raw material, they point out, is 150- to 190-proof wet ethanol produced in nonbeneficiary countries such as Spain. It then is dried in a "relatively simple distillation process in CBI countries to 200-proof, fuel-grade ethanol. That hardly represents a "substantial manufacturing process" producing a "new or different article of commerce," they argue.

Once again, the economic and foreign relations stakes are high. The Tropicana project and others like it in the planning stage were initiated with the Customs ruling in mind. A reversal, if it should come, would hit these projects hard.

In Jamaica, most of Tropicana's feedstock is wet ethanol from Spain. Now, it is trying to line up locally produced ethanol. So far, local volumes are small, but the company hopes to use 100% local feedstock in two years.

Domestic producers obviously feel that the economic shoe will be on the other foot if this and future CBI fuel ethanol enter the country duty free. Senate majority leader Robert J. Dole (R.-Kan.) agrees. He has introduced legislation to prevent what he calls "abuse" of the CBI program by Spanish, Brazilian, and other

ethanol exporters who are trying to use CBI beneficiary countries to evade U.S. tariffs.

Dole's bill makes it clear that simply distilling or denaturing alcohol does not qualify a product as that of a CBI country. He emphasizes, however, that his bill is not intended to disallow duty-free treatment of ethanol that is a legitimate product of a CBI beneficiary country.

Sen. Dole also has introduced a companion bill to close yet another loophole in U.S. trade laws. The domestic industry has long complained that foreign ethanol producers are exploiting a loophole by mixing their ethanol with gasoline and shipping the blend to the U.S. The duty on gasoline and gasoline blends is 1.25 cents per gal—a far cry from the 60 cents assessed on fuel ethanol. Nobody really knows how much fuel ethanol comes into the U.S. in blends, but the feeling is that it is substantial.

Sen. Dole's bill would make mixtures containing ethanol subject to the 60-cent tariff if they are suitable for fuel use. It also would require that duties be assessed as soon as the imported material enters the country instead of later, when the importer may declare its use as a fuel. This, says the Senator, will prevent imported ethanol from becoming "lost." It also will deprive importers of a possible three-year, interest-free loan amounting to the duties that they owe.

Clearly the battle over fuel ethanol imports is intense. And it may become more intense before it is over. It's more than a question of markets and economics. Government policies and international relationships are inexorably involved. Whether these relationships will play a role in how the various U.S. agencies decide the import issues before them remains to be seen.

Only time will tell if a huge fuel ethanol market will develop in the U.S. as a result of lead additive phasedown and the Du Pont waiver. If it does, only then will everyone know if the U.S. industry will be able to meet the challenge or if imports will be needed to fill the supply-demand gap.

Industry expert David E. Hallberg thinks that imported fuel ethanol has a definite role to play in the U.S. fuels market. A former president of the domestically oriented Renewable Fuels Association, Hallberg is now president of the Washington Energy Trade & Agriculture Group. He stresses that the ethanol fuels industry is entering the second phase of its development just as a series of converging developments present it with major market opportunities.

There's more than a little concern about the life span of some domestic subsidy and loan guarantee programs. This raises the question of how domestic producers will fare without federal and state aid.

For these and other reasons, Hallberg thinks that imported fuel ethanol can fit in, especially in states without tax exemptions. The large marketing niche that this will open up, he says, will benefit all parties—octane-short refiners, U.S. ethanol producers, foreign ethanol producers, methanol producers, and the U.S. motorist. □

Little Growth Ahead For Major Mineral Acids

Slowing in demand will mean continuing overcapacity for sulfuric, rough balance with supply for phosphoric, and changes in trade for both

Bruce F. Greek, C&EN Houston

Stagnating growth in demand this year for major mineral acids—sulfuric and phosphoric—is forcing producers to take a long, hard look at their longer-term prospects. But for the rest of the 1980s, it looks like relatively small net growth for sulfuric acid and somewhat better growth for phosphoric acid.

A slowdown in demand would affect these two acids in distinctly different ways. One significant difference would be a large and continuing overcapacity for sulfuric acid, but a rough balance in supply and demand for phosphoric acid. Another difference might be changes

in trade trends, with exports of phosphoric acid rising, on the one hand, and imports of sulfuric acid rising on the other. And various nonfertilizer uses of these acids may be in store, which could mean less dependence of sulfuric acid on phosphoric acid's fortunes.

A slowdown in demand growth this year after a big gain in 1984 was to be expected, especially as the general economic growth also slows. In coming years, forecasts of

Key Chemicals

consumption of these acids become obscured by such uncertainties as export demand, U.S. farm economics, and changes in industrial applications.

During recent years of recovery from a severe recession, growth in demand for sulfuric acid has been dominated by its use in making phosphoric acid. The share of sulfuric acid for this use will continue to increase, but more slowly, because other industrial applications will decline, owing to slowing demand for such end products as steel or to such process changes as a shift to the chloride process for making titanium dioxide.

Meanwhile, imports of sulfuric acid are increasing, mainly from Canada. This imported acid often is low-price coproduct smelter acid. Smelter acid is primarily used in metals manufacturing, currently a depressed industry.

In taking a long-term look at the future of sulfuric acid, producers could be evaluating the economics of shipping the acid from large and newer plants. These plants could be used more fully and have lower unit costs than those of old plants

being operated at low rates with high maintenance costs. The result of such studies could be future shut-downs of plants in parts of the U.S. where little or no phosphoric acid is made.

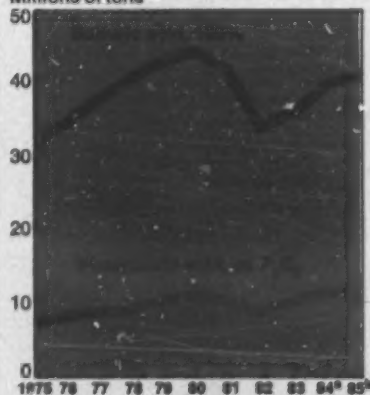
As for phosphoric acid's longer-term outlook, demand for phosphate fertilizers is expected to continue to rise slowly because of efforts to increase yields per acre and to some extent to increase planted acreage despite set-aside programs. Exports of phosphate fertilizers also could remain roughly at current levels or even rise slowly.

The continuing strong export demand has vindicated phosphoric acid producers who built capacity around the beginning of the 1980s. Although no more phosphoric acid capacity is slated for some time, it will be needed before 1990, according to some forecasts, for fertilizer demand.

For a more detailed look at the near-term outlook for these acids, please see the following pages.

Phosphoric sets output record, sulfuric still lags

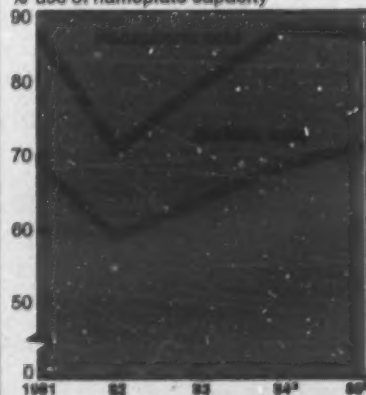
Millions of tons



▲ Preliminary, ■ Estimated. Sources: Department of Commerce, C&EN estimates

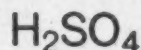
Capacity use of mineral acids recovers well

% use of nameplate capacity



▲ Preliminary, ■ Estimated. Sources: Department of Commerce, C&EN estimates

Key Chemicals

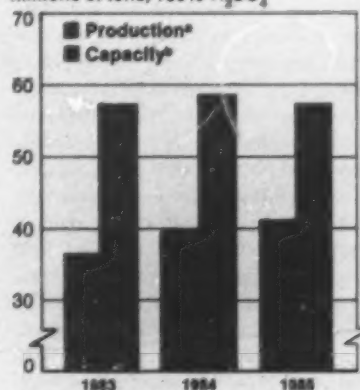


Sulfuric acid

- *Production up modestly*
- *Capacity off again*
- *Prices slightly higher*

PRODUCTION/CAPACITY

Millions of tons, 100% H_2SO_4



a From all sources. b First quarter.

MAJOR PRODUCERS

Allied, Du Pont, Monsanto, Olin, Stauffer Chemical

HOW MADE

Sulfur dioxide made by burning sulfur or recovered from smelting, oxidized, and reacted with water

MAJOR DERIVATIVES (U.S.)

None more than 5% of production

MAJOR END USES (U.S.)

Fertilizer manufacturing 70%, metals processing 10%

FOREIGN TRADE

Exports—could rise to 150,000 tons in 1985, imports—remaining around 500,000 tons in 1985

PRICES

List for smelter acid, \$20 to \$50 per ton; for virgin acid, \$55 to \$95 per ton

Prospects for sulfuric acid in 1985 are for a further net decline in capacity, a small gain in production if fertilizer and industrial uses are up slightly, and the usual price pressure, minimizing profitability in spite of marketers' best efforts.

Output of sulfuric acid—the largest-volume chemical produced in the U.S.—is expected to increase modestly this year to 41.0 million tons (expressed as 100% product) following a substantial rise in 1984. This slowing of growth is to be expected in a year in which economic expansion has been slowing. But causes of the slowdown this year are more than simply the general level of the economy. They include slowing of exports of phosphate fertilizers, which consume by far the largest share of sulfuric acid.

Actual increase in 1985 sulfuric acid production could be less than 1 million tons of 100% H_2SO_4 , or about 2% over 1984 production of 39.9 million tons. However, a small increase is normally expected for such a major-volume product after a large gain in the preceding year. The 1984 production gain was more than 3.4 million tons measured as 100% acid, a 9.3% increase over 1983 output.

Capacity to make sulfuric acid declined during 1984. Part of the net decline of about 500,000 tons came as a result of a shutdown of a major copper smelter, ending its production of by-product acid. Other smelter acid capacity is expected to be either completely shut down or drastically reduced during 1985. Some virgin acid production, going mostly to various industrial uses such as steelmaking, also has been shut down and more will be closed down this year. Offsetting the declines in smelter by-product acid and acid produced for industrial uses will be minor gains in capacity used to make phosphoric acid for fertilizers.

As 1985 began, estimated nameplate capacity to make sulfuric acid from its various sources—including burning of sulfur, recovery from smelt-

er operations, and roasting pyrites—is about 57.5 million tons of 100% acid. Most of this capacity will be available for production during 1985. Thus, the average capacity utilization rate for all plants will be a bit over 71%.

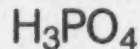
In addition to acid production from the various sources, some 350,000 tons will be added to the supply as a net of imports over exports. The major source of imported sulfuric acid is Canada and much of this is smelter acid (because of pollution regulations, sulfur dioxide can't be released to the atmosphere, and so is converted to sulfuric acid). The major destination of U.S. exports of the acid is Mexico—mostly smelter acid eventually used in diverse small applications such as automobile batteries.

Imported sulfuric acid, most heavily sold from the upper Midwest to the northeastern U.S., keeps pressure on prices for merchant acid. Other price pressure comes from recovered sulfur, which is moved to markets as quickly as possible from desulfurization units at refineries and gas processing plants. The result is a wide range of prices for sulfuric acid.

In 1984, prices for elemental sulfur, especially Frasch sulfur, rose about 17% as three price increases for Frasch sulfur accounted for a total of \$25 per long ton, bringing the terminal price at Tampa, Fla., to \$147.50 per ton after discounts. Merchant acid prices also rose, but not by this much, because of the large overcapacity. A large gain in phosphate fertilizer exports with accompanying higher prices allowed captive sulfuric acid producers to pass on part of their increased costs of sulfur during 1985.

Sulfuric acid's major captive use, some 70% of production, in making phosphoric acid and other fertilizer materials, will not grow much in 1985. The other uses of sulfuric acid, such as in metals processing, petroleum refining, and manufacture of many different chemicals, also will grow slowly this year.

Key Chemicals

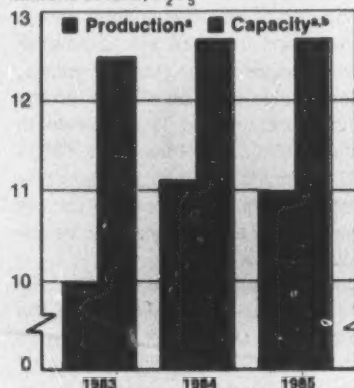


Phosphoric acid

- **Production to slow**
- **Capacity holding**
- **Prices poor**

PRODUCTION/CAPACITY

Millions of tons, P_2O_5



^a Wet process and furnacc, ^b First quarter.

MAJOR PRODUCERS

CF Industries, Freeport Chemical, Occidental Chemical, Texasgulf Chemicals, Williams Cos.

HOW MADE

Reaction of phosphate rock with sulfuric acid; burning of elemental phosphorus and subsequent reaction with water

MAJOR DERIVATIVES (U.S.)

Ammonium phosphates 60%, triple superphosphate 15%

MAJOR END USES (U.S.)

Fertilizers 85%, detergent materials 5%

FOREIGN TRADE (as acid)

Exports—holding at about 750,000 tons of P_2O_5 in 1985, imports—below 25,000 tons of P_2O_5 in 1985

PRICES

List about \$300 per ton of P_2O_5

Producers of phosphoric acid and its derivatives are watching domestic and export fertilizer markets closely this spring. These swing markets are in a situation similar to that of a year ago when demand had improved. However, export demand for phosphate fertilizers is forecast to weaken later in the year and U.S. fertilizer inventories are expected to be inordinately high.

Slowing fertilizer exports and inventory cutting this summer will cause 1985 output of phosphoric acid to decline about 1% from the 11.1 million tons as P_2O_5 produced in 1984.

Most phosphoric acid (wet acid) is produced by reacting sulfuric acid with phosphate rock that has been processed to increase the concentration of phosphorus in it. A small amount of phosphoric acid (thermal acid) is made by burning elemental phosphorus made in electric furnaces and reacting the P_2O_5 gas with water. Thermal acid accounts for 5 to 10% of total phosphoric acid production, depending on general economic conditions.

If the 1984 production estimate for phosphoric acid holds at 11.1 million tons of P_2O_5 or is revised higher, then it is a new output record. But it will not be much more than the previous high set in 1980 of slightly more than 11 million tons. This year has a chance of being the second highest production year on record.

Even if phosphoric acid production declines more than 1% in 1985, producers will have two good years back to back. The 1984 production was up 11% over 1983, which was devastated by the federal government's payment-in-kind program aimed at reducing crop production. Plant operating rates will average around 87% of nameplate capacity this year, down slightly from 1984.

High plant operating rates have not improved prices for phosphoric acid very much. Some of the sulfur price increases were passed on during 1984 and in early 1985 when U.S. spring fertilizer demand was anticipated to

be better after a disappointing fall sales program. Even so, producers' returns haven't changed much as discounts off the list prices for both acid and major derivatives such as diammonium phosphate remain large.

U.S. demand for phosphate fertilizers during 1985 is expected to increase even though financial troubles appear to be widespread among farmers and planted acreage may be down. The scenario includes a spring demand about equal to the strong spring demand of 1984 and a better fall demand than last year. The annual total gain, however, will be small, probably about 300,000 tons of P_2O_5 equivalent.

Some reduction in inventories built last summer will offset the gain in demand for fertilizers and will hold down production over the year. At this time, inventories don't appear to be excessive and interest rates are down. If exports fall as expected this summer, then inventory reduction will follow during the latter part of the third quarter. Plant output will be limited by temporary shutdowns for maintenance.

Exports of phosphate fertilizers and phosphoric acid increased substantially during 1984 to a new high of about 5.2 million tons, as P_2O_5 . Inventories were replenished in some major buying countries such as India and were built up to stay ahead of the then-fast-rising value of the dollar. Even with a partial weakening of the dollar now under way, export sales will have to contend with these inventories. As a result, forecasts call for total exports of phosphate this year to be below 1984 exports, possibly amounting to less than 4.7 million tons of P_2O_5 , but more likely about 4.9 million tons.

The net difference between the export decline in phosphate fertilizers and the increase in domestic use accounts for the forecast of a slight decline in phosphoric acid production in the U.S. during 1985. Nonfertilizer uses of phosphoric acid are small and will not have any effect on the total production and use.

Urbana dominates graduate rankings

In terms of sheer numbers of new chemistry graduates, 1983-84 was a big academic year for the University of Illinois, Urbana-Champaign, a school long a major force in chemical education. Last year it produced more chemistry graduates with bachelor's degrees than any other institution in the U.S. It produced the highest number of such graduates with degrees certified by the American Chemical Society. And it ranked second in production of new Ph.D. chemists and 19th in the output of masters chemistry graduates.

This is but one of the many facts that can be gleaned from the latest annual report of ACS's Committee on Professional Training (CPT), the group through which the society sets standards for chemistry undergraduate programs and monitors them. The full report starts on page 58.

For nine of the previous 10 years the University of North Carolina, Chapel Hill, had been the largest producer of new bachelor's chemists. But last year it slipped to third as Illinois moved ahead. Indiana University retained the second position it has held since 1980-81.

Illinois, Urbana-Champaign, last year became the fourth school to top the ranking of certified bachelor chemist producers in as many years. It displaced the University of Michigan, which, in turn, had claimed the top spot from Rutgers University. The University of California, San Diego, had headed this list for the eight years ending 1980-81. Certified graduates have completed a curriculum that makes them immediately eligible for ACS membership.

Illinois has been the largest producer of chemistry Ph.D. graduates for eight of the past 11 years. In 1983-84 it was exceeded by the University of California, Berkeley, as it was in both 1979-80 and 1981-82.

The biggest producer of new M.S. graduates last year was the University of Michigan, up from ninth the year before. Cornell University, the leader in 1982-83, slipped to third.

These schools had the most chemistry graduates, 1983-84

Total bachelor graduates

1. U of Illinois, Urbana-Champaign	139
2. Indiana U	135
3. U of North Carolina, Chapel Hill	129
4. U of California, Los Angeles	116
5. U of Virginia	83
6. Duke U	82
7. U of Miami	81
8. U of Pittsburgh	79
9. U of South Florida	79
10. U of Delaware	71
11. Emory U	60
12. U of Colorado	67
13. U of Maryland, College Park	66
13. Miami U	66
15. Cornell U	60
15. Rutgers U	60
17. California Polytechnic State U	58
17. U of California, Irvine	58
19. U of California, San Diego	57
19. Illinois State U	57
19. State U of New York, Stony Brook	57
19. U of Washington	57
23. U of California, Berkeley	56
24. St. Olaf C	55
25. U of Florida	54
25. U of Puerto Rico	54

Certified bachelor graduates

1. U of Illinois, Urbana-Champaign	66
2. U of California, San Diego	57
3. Illinois State U	58
4. U of California, Berkeley	53
4. U of Michigan	51
6. U of Delaware	51
7. U of Texas	50
8. Rutgers U	48
9. Indiana U	42
10. Massachusetts Inst. of Tech	40
11. U of North Carolina, Chapel Hill	39
12. U of California, Los Angeles	38
13. Purdue U	34
14. U of Washington	31
15. Rensselaer Polytechnic Inst.	30
15. State U of New York, Albany	30
17. U of California, Davis	29
18. Miami U	28
18. Ohio State U	28
20. U of Connecticut	27
20. Cornell U	27
20. San Jose State U	27
20. Virginia Polytechnic Inst.	27
24. U of Minnesota	26
25. Duke U	24
25. C of the Holy Cross	24

Masters graduates

1. U of Michigan	35
2. Northwestern U	32
3. Cornell U	28
3. U of Rochester	28
5. U of Cincinnati	26
6. Yale U	24
7. U of Illinois, Chicago	23
8. Columbia U	21
9. New York U	19
10. Princeton U	18
10. Rensselaer Polytechnic Inst.	18
12. U of Scranton	17
13. U of California, San Diego	16
13. U of Pittsburgh	16
13. U of Washington	16
16. Lawrence U	15
16. U of Maryland, College Park	15
16. Purdue U	15
19. U of Georgia	14
19. U of Illinois, Urbana-Champaign	14
21. U of Massachusetts	13
21. Rutgers U	13
21. U of Texas	13
24. U of Delaware	12
24. Drexel U	12
24. Iowa State U	12
24. U of North Carolina, Chapel Hill	12

Doctoral graduates

1. U of California, Berkeley	62
2. U of Illinois, Urbana-Champaign	62
3. Pennsylvania State U	36
4. Massachusetts Inst. of Tech	36
5. Texas A&M U	36
6. Indiana U	33
7. California Inst. of Tech	31
7. Iowa State U	31
9. U of Minnesota	30
9. Purdue U	30
11. U of California, Los Angeles	29
11. Cornell U	29
13. U of Colorado	27
13. Ohio State U	27
13. U of Wisconsin, Madison	27
16. U of California, San Diego	26
16. U of North Carolina, Chapel Hill	25
18. Harvard U	24
18. U of Maryland, College Park	24
18. Michigan State U	24
21. Yale U	23
22. U of Michigan	21
22. U of Pennsylvania	21
24. U of Delaware	19
24. Princeton U	19

ACS Committee on Professional Training 1984 Annual Report

The number of bachelor's degree graduates in chemistry from colleges and universities whose undergraduate chemistry programs are approved by the American Chemical Society decreased about 2% in the 1983-84 academic year from the previous year. The number of master's degrees from these departments rose 4%, and the number of Ph.D. degrees continued to rise for the fifth year in a row, this year by 1%. These departments project increases for 1986 of 7% for bachelor's degrees, 17% for both master's and Ph.D. degrees. (It should be noted that these projections are usually higher than actual counts a year later.)

The percentage of baccalaureate graduates certified to ACS was 43%, up slightly from the 41 and 42% of previous years. (Certified graduates are those who have completed the curriculum specified by the Committee on Professional Training and are eligible for full membership in ACS; noncertified graduates may become associate members of ACS upon graduation and full members after three years of professional experience or a higher degree in a chemical science.)

A total of 2371 of the bachelor's degree graduates from the approved schools were reported as planning to go to graduate school; 2111, to go to professional schools.

Total numbers of bachelor's degrees, master's degrees, and Ph.D.

Summary of data from approved schools, 1980-84

	Bachelors				Masters		Doctorates	
	Number of schools	Graduates (totals)	Certified graduates	Non-certified graduates	Number of schools	Graduates	Number of schools	Graduates
CHEMISTRY								
1980	554	10,170	4170	6000	324	1698	186	1561
1981	558	10,453	4337	6116	323	1609	187	1613
1982	561	9,866	4179	5687	322	1645	187	1683
1983	570	10,043	4233	5810	320	1569	189	1759
1984	577	9,819	4201	5618	321	1637	189	1777
CHEMICAL ENGINEERING^a								
1980	109	5,348	5348	—	105	974	88	243
1981	110	5,831	5831	—	106	1020	87	250
1982	113	5,963	5963	—	109	1171	92	293
1983	122	7,021	7021	—	116	1317	101	333
1984	120	6,866	6866	—	114	1436	101	357

^a Chemical engineering departments are not required to report their data to CPT, so the number of departments included in this category varies from year to year.

degrees awarded in 1983-84 by departments whose chemistry programs are ACS approved are listed by institution in the large table at the end of this report and are summarized in the two smaller tables. These tables also include numbers of chemical engineering graduates from institutions whose programs are accredited by the American Institute of Chemical Engineers and the Accreditation Board for Engineering & Technology. (Note: These departments are not required to report their data to CPT, so the number of departments included varies each year.) Included for the third year is a table with information on graduate student enrollments in chemistry departments whose undergraduate programs are ACS approved.

The number of bachelor's degrees in chemical engineering from the 120 AICHE-ABET-accredited departments that reported in 1984 decreased about 2% from the total reported by 122 departments in 1983, the first decrease in this number since 1975. These 120 departments reported an expected further decrease in bachelor's degrees of nearly 4% in 1985. At the graduate level, the number of both chemical engineering master's and Ph.D. degrees increased for the fifth year in a row.

The number of master's degrees was up 9% from 1983, and the number of Ph.D.'s was up 7%. Projected increases for 1986 in numbers of master's and Ph.D. degrees in chemical engineering from these schools are 3% and 6%, respectively.

The chemistry programs at ACS-approved schools normally are re-evaluated at five-year intervals. There were 580 colleges and universities on the approved list at the end of 1984. During the year, the committee studied the chemistry programs of 161 of the approved schools and of 13 schools applying for ACS approval. Each evaluation involved a review of extensive documentary materials submitted by the department describing the status of the program.

During 1984, 10 schools were added to the ACS-approved list, seven schools were put on probation, two were removed from probation, two were continued on probation, and two schools were removed from the approved list.

In fall 1983, the committee published its revised guidelines for ACS-approved schools. As part of this revision, ACS divisions had been asked to participate in preparing recommendations of the topics that should be covered in an undergrad-

Summary of totals from 1984 reports from approved schools

	Number of schools	Number of graduates	Number of certified graduates	Number of non-certified graduates
CHEMISTRY				
Bachelor's	577	9,819	4,201	5,618
Master's	321	1,637	—	—
Ph.D.	189	1,777	—	—
CHEMICAL ENGINEERING				
Bachelor's	120	6,866	6,866	—
Master's	114	1,436	—	—
Ph.D.	101	357	—	—

uate course in each specialty. Appendix materials were accordingly assembled for analytical chemistry, biochemistry, chemical health and safety, chemical information retrieval, computers in chemistry, industrial chemistry, inorganic chemistry, organic chemistry, and polymer chemistry and sent to the ACS-approved schools in May 1984.

To spread discussion on proposed changes in the guidelines for ACS-approved schools over a period of time and to share thoughts concerned with undergraduate chemical education with the approved schools, the committee decided to prepare and send to the approved schools from time to time position papers on topics of mutual interest. The first two in this series, "Qualitative Organic Analysis Course" and "Advanced Synthesis Laboratory," were sent to the approved schools in fall 1984, and the third, "Biochemistry in the Core Curriculum," was prepared

Graduate student enrollments in departments whose undergraduate chemistry programs are ACS approved

	Number of departments	First-year graduate students		All graduate students	
		Fall 1983	Fall 1982	Fall 1983	Fall 1982
U.S. departments^a					
Fall 1981	135	448	366	1,073	1044
Fall 1982	131	484	310	1,075	1042
Fall 1983	132	452	299	1,096	991
P.R.D. departments					
Fall 1981	187	3248	311	12,836	1518
Fall 1982	188	3412	306	13,488	1483
Fall 1983	189	3554	275	14,037	1390

^a Departments whose highest offering is the master's degree in chemistry.

for mailing in January 1985. Comments and suggestions on all three were invited.

In an effort to keep abreast of trends in chemical education and to remain current in its understanding of the various needs and situations of the schools on the ACS-approved list, the committee instituted a series of visits by two-person teams from the committee to representative institutions on the approved list. Three visits were made in 1984, and nine more are planned for 1985.

The committee decided to prepare a CPT newsletter to be sent to all chemistry faculty members in four-year colleges and universities in the U.S. and also, for the first issue, to each two-year college chemistry program. The purpose of the newsletter is to highlight issues in chemical education that are currently being discussed by the committee, to provide information on new projects the committee is undertaking, and to invite comments and suggestions concerning CPT-related issues from chemistry faculty members.

Preparation of the DGR Online, a computerized database of all information in the 1983 ACS Directory of Graduate Research as well as a multidimensional concordance of the research interests of the faculty members listed in this edition, continued and was scheduled to be completed in early 1985. The database is available through Bibliographic Retrieval Services. Further information on the file may be obtained from Cathy A. Nelson, ACS Office of Professional Training, 1155-16th St., N.W., Washington, D.C. 20036, telephone (202) 872-4599.

The committee set up a two-year plan for computerizing the data received from the ACS-approved

schools. When fully implemented, the new procedure should simplify the way in which departments send updated information on their programs to the committee, facilitate the committee's review of these materials, and provide the chemical education community with a valuable source of data useful in its program planning and evaluation.

A task force to discuss the issue of biochemistry at the undergraduate level was established with representatives from the American Society of Biological Chemists, and CPT representatives were asked to meet with the Panel on Service Courses of the Mathematical Association of America to discuss the nature of the mathematics courses given to chemistry majors.

The committee would like to acknowledge and thank the following visiting associates of the committee who conducted on-site visits to schools on the approved list or applying for ACS approval during 1984: Martin N. Ackermann, Oberlin College; Virgil Boekelheide, University of Oregon; Alan F. Clifford, Virginia Polytechnic Institute & State University; C. Daniel Cornwell, University of Wisconsin; LeRoy Eyring, Arizona State University; Stuart W. Fenton, University of Minnesota; Albert E. Finholt, St. Olaf College; David M. Grant, University of Utah; Donald E. Jones, Western Maryland College; Charles A. Root, Bucknell University; William F. Sager, University of Illinois, Chicago; William H. Saunders, University of Rochester; Barbara R. Shaw, Duke University; Cheves Walling, University of Utah; Robert I. Walter, University of Illinois, Chicago; Theodore R. Williams, College of Wooster.

Chemistry and chemical engineering degrees awarded by approved schools, 1983-84

	CHEMISTRY				CHEMICAL ENGINEERING				CHEMISTRY				CHEMICAL ENGINEERING			
	Bachelor's certified		M.S.	Ph.D.	B.S.		M.S.	Ph.D.	Bachelor's certified		M.S.	Ph.D.	B.S.		M.S.	Ph.D.
	Yes	No							Yes	No						
Abilene Christian U	6	4	2	—	—	—	—	—	6	9	—	—	—	—	—	—
Adelphi U	6	4	6	1	—	—	—	—	11	5	—	—	—	—	—	—
Agnes Scott C	2	1	—	—	—	—	—	—	2	8	—	—	—	—	—	—
Akron, U of	6	8	8	4	a	—	—	—	3	32	—	—	—	—	—	—
Alabama, U of	—	—	—	—	—	—	—	—	22	0	10	8	82	4	9	—
University	2	11	1	6	34	5	1	—	3	7	—	—	—	—	—	—
Birmingham	5	1	3	1	—	—	—	—	Carroll C	3	3	—	—	—	—	—
Huntsville	5	6	1	—	—	—	—	—	Carthage C	7	28	4	9	51	16	2
Alaska, U of	3	1	0	—	—	—	—	—	Case Western Reserve U	0	2	5	1	a	—	—
Albion C	2	12	—	—	—	—	—	—	Catholic U of America	0	4	—	—	—	—	—
Albright C	7	17	—	—	—	—	—	—	Centenary C of Louisiana	0	3	—	—	—	—	—
Alfred U	5	0	—	—	—	—	—	—	Central C	10	1	1	—	—	—	—
Allegheny C	1	23	—	—	—	—	—	—	Central Connecticut State U	15	0	6	—	—	—	—
Alma C	3	9	—	—	—	—	—	—	Central Florida, U of	2	13	4	—	—	—	—
American U	6	2	9	7	—	—	—	—	Central Michigan U	2	2	—	—	—	—	—
Amherst C	3	9	—	—	—	—	—	—	Central State U (Ohio)	0	10	—	—	—	—	—
Andrews U	6	11	—	—	—	—	—	—	Central State U (Oklahoma)	0	4	—	—	—	—	—
Appalachian State U	0	7	0	—	—	—	—	—	Centre C	2	9	—	—	—	—	—
Arizona State U	18	10	2	7	37	10	1	—	Charleston, C of	3	1	—	—	—	—	—
Arizona, U of	7	19	11	14	45	8	1	—	Chatham C	4	3	—	—	—	—	—
Arkansas, U of	—	—	—	—	—	—	—	—	Chestnut Hill C	9	32	5	13	—	—	—
Fayetteville	8	3	1	7	39	19	4	—	Chicago, U of	22	0	25	17	66	8	4
Little Rock	3	8	1	—	—	—	—	—	Cincinnati, U of	1	3	—	—	—	—	—
Ashland C	0	1	—	—	—	—	—	—	Citadel, The	—	—	—	—	—	—	—
Auburn U	6	38	5	5	91	7	2	—	City U of New York	—	—	—	16	—	—	—
Augsburg C	2	13	—	—	—	—	—	—	Graduate Center	—	—	—	—	—	—	—
Augustana C (Illinois)	1	17	—	—	—	—	—	—	Brooklyn College	1	24	3	—	—	—	—
Augustana C (South Dakota)	3	5	—	—	—	—	—	—	City College	4	11	3	—	a	—	—
Austin C	0	10	—	—	—	—	—	—	Herbert H. Lehman College	5	5	—	—	—	—	—
Baldwin-Wallace C	2	5	—	—	—	—	—	—	Hunter College	3	9	—	—	—	—	—
Ball State U	7	3	2	—	—	—	—	—	Queens College	4	23	5	—	—	—	—
Barnard C	0	13	—	—	—	—	—	—	Clarion U of Pennsylvania	5	1	—	—	—	—	—
Bates C	2	5	—	—	—	—	—	—	Clark U	15	1	3	2	—	—	—
Baylor U	13	15	4	0	—	—	—	—	Clarkson U	9	0	9	6	130	19	7
Beloit C	2	9	—	—	—	—	—	—	Clemson U	6	2	6	4	66	9	0
Bemidji State U	5	7	0	—	—	—	—	—	Cleveland State U	10	0	7	6	39	10	2
Birmingham-Southern C	3	14	—	—	—	—	—	—	Coe C	0	5	—	—	—	—	—
Bloomsburg U	8	1	—	—	—	—	—	—	Colby C	4	7	—	—	—	—	—
Boston C	8	17	6	3	—	—	—	—	Colgate U	1	19	—	—	—	—	—
Boston U	0	16	3	4	—	—	—	—	Colorado C	6	4	—	—	—	—	—
Bowdoin C	0	37	—	—	—	—	—	—	Colorado School of Mines	7	0	4	2	82	14	0
Bowling Green State U	8	19	11	—	—	—	—	—	Colorado State U	16	8	0	7	20	10	0
Bradley U	5	6	0	—	—	—	—	—	Colorado, U of	18	49	7	27	84	8	2
Brandeis U	0	19	11	13	—	—	—	—	Boulder	6	4	—	—	—	—	—
Bridgeport, U of	3	1	8	—	—	—	—	—	Colorado Springs	6	16	4	—	—	—	—
Bridgewater State C	1	9	0	—	—	—	—	—	Denver	4	11	21	18	47	42	7
Brigham Young U	5	16	2	6	55	6	3	—	Columbia U	4	2	—	—	—	—	—
Brown U	0	9	2	16	—	—	—	—	Concordia C	27	9	6	6	60	7	5
Bryn Mawr C	19	0	2	2	—	—	—	—	Connecticut, U of	—	—	—	—	29	6	—
Bucknell U	15	17	2	—	21	4	—	—	Cooper Union ^b	0	7	—	—	—	—	—
Butler U	2	6	5	—	—	—	—	—	Cornell C	27	33	28	29	68	19	5
California Institute of Tech	10	0	5	31	20	9	11	—	Cornell U	2	31	2	—	—	—	—
California Polytechnic State U	16	42	6	—	—	—	—	—	Creighton U	0	25	1	6	—	—	—
California State C	—	—	—	—	—	—	—	—	Dartmouth C	1	19	—	—	—	—	—
Bakersfield	6	2	—	—	—	—	—	—	David Lipscomb C	8	8	—	—	—	—	—
San Bernardino	0	1	—	—	—	—	—	—	Davidson C	8	8	1	—	a	—	—
Stanislaus	1	3	—	—	—	—	—	—	Dayton, U of	1	2	—	—	—	—	—
California State Polytechnic U	9	4	3	—	45	—	—	—	Delaware State C	51	20	12	19	59	14	8
California State U	—	—	—	—	—	—	—	—	Delaware, U of	7	0	—	—	—	—	—
Chico	2	7	—	—	—	—	—	—	Delaware Valley C of Science & Agriculture	0	13	—	—	—	—	—
Dominguez Hills	5	5	—	—	—	—	—	—	Delta State U	6	3	—	—	—	—	—
Fresno	10	8	7	—	—	—	—	—	Denison U	5	12	7	1	—	—	—
Fullerton	8	16	5	—	—	—	—	—	Denver, U of	1	1	4	—	—	—	—
Hayward	10	15	1	—	—	—	—	—	De Paul U	6	11	—	—	—	—	—
Long Beach	8	25	7	—	56	—	—	—	DePauw U	5	2	9	4	14	9	—
Los Angeles	14	0	3	—	—	—	—	—	Detroit, U of	9	18	—	—	—	—	—
Northridge	16	10	3	—	—	—	—	—	Dickinson C	4	6	—	—	—	—	—
Sacramento	17	4	4	—	—	—	—	—	Drake U	1	9	—	—	—	—	—
California, U of	—	—	—	—	—	—	—	—	Drew U	10	1	12	10	86	18	2
Berkeley	53	3	8	62	119	16	26	—	Drexel U	24	58	4	14	—	—	—
Davis	29	7	5	16	57	16	2	—	Duke U	1	3	6	3	—	—	—
Irvine	17	41	10	17	—	—	—	—	Duquesne U	1	12	—	—	—	—	—
Los Angeles	36	80	6	29	13	13	3	—	Earlham C	5	5	2	—	—	—	—
Riverside	11	2	9	11	—	—	—	—	East Carolina U	4	13	0	—	—	—	—
San Diego	57	0	16	25	—	—	—	—	East Stroudsburg U	7	12	1	—	—	—	—
Santa Barbara	14	8	7	15	a	—	—	—	East Tennessee State U	1	2	0	—	—	—	—
Santa Cruz	18	13	8	9	—	—	—	—	East Texas State U	—	—	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING			CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified		M.S.	Ph.D.	B.S.	M.S.	Ph.D.	Bachelor's certified		M.S.	Ph.D.	B.S.	M.S.	Ph.D.
	Yes	No						Yes	No					
Eastern Illinois U	6	8	5	—	—	—	—	17	0	10	8	19	5	0
Eastern Kentucky U	2	14	1	—	—	—	—	5	22	—	—	—	—	—
Eastern Michigan U	1	22	7	—	—	—	—	8	12	—	—	—	—	—
Eastern New Mexico U	1	5	2	—	—	—	—	11	2	2	4	33	7	1
Eckerd C	3	3	—	—	—	—	—	14	20	5	8	55	10	2
Elizabethtown C	3	11	—	—	—	—	—	9	2	—	—	—	—	—
Elmhurst C	3	12	—	—	—	—	—	0	6	—	—	—	—	—
Emory U	1	68	2	8	—	—	—	6	6	0	5	—	—	—
Emporia State U	2	9	1	—	—	—	—	8	15	3	3	56	15	1
Evansville, U of	1	3	—	—	—	—	—	7	7	—	—	—	—	—
Fairfield U	11	5	—	—	—	—	—	5	3	—	—	—	—	—
Fairleigh Dickinson U	8	7	5	—	—	—	—	2	17	—	—	—	—	—
Madison	2	2	4	—	—	—	—	7	6	—	—	50	—	—
Rutherford	15	0	4	—	—	—	—	2	10	—	—	—	—	—
Teaneck	14	0	6	—	—	—	—	10	0	2	—	36	9	0
Fisk U	2	14	2	0	—	—	—	6	2	—	—	—	—	—
Florida Atlantic U	0	4	0	—	10	0	—	10	0	—	—	—	—	—
Florida Institute of Tech	6	10	0	—	—	—	—	3	5	15	6	—	—	—
Florida International U	7	26	3	10	—	—	—	2	5	—	—	—	—	—
Florida State U	8	46	6	17	44	25	3	16	0	10	15	90	31	12
Florida, U of	4	18	4	—	—	—	—	10	0	—	—	—	—	—
Fordham U	3	9	—	—	—	—	—	1	4	—	—	—	—	—
Fort Lewis C	13	14	—	—	—	—	—	—	—	—	—	—	—	—
Franklin & Marshall C	11	2	2	—	—	—	—	1	3	4	—	—	—	—
Furman U	1	8	—	—	—	—	—	6	0	—	—	—	—	—
Geneva C	8	7	—	—	—	—	—	2	1	—	—	—	—	—
George Mason U	7	12	1	5	—	—	—	4	9	0	9	65	15	1
George Washington U	14	0	8	7	—	—	—	2	0	—	—	—	—	—
Georgetown U	13	0	6	15	145	28	4	2	2	1	—	25	3	0
Georgia Institute of Tech	3	4	3	—	—	—	—	10	19	2	1	—	20	1
Georgia State U	6	28	14	16	—	—	—	8	3	3	5	a	—	—
Georgia, U of	3	6	—	—	—	—	—	5	2	—	—	—	—	—
Gettysburg C	8	2	—	—	—	—	—	4	0	—	—	—	—	—
Glassboro State C	1	4	—	—	—	—	—	1	0	—	—	—	—	—
Gonzaga U	1	3	—	—	—	—	—	13	16	4	1	—	—	—
Goucher C	3	13	—	—	—	—	—	0	11	—	—	—	—	—
Grand Valley State C	1	18	—	—	—	—	—	4	3	—	—	—	—	—
Grinnell C	4	8	—	—	—	—	—	7	4	3	0	38	3	0
Gustavus Adolphus C	0	3	—	—	—	—	—	16	2	—	—	52	35	—
Hamilton C	11	6	—	—	—	—	—	3	0	—	—	—	—	—
Hamline U	9	2	—	—	—	—	—	9	9	—	—	—	—	—
Hampden-Sydney C	3	4	0	—	—	—	—	3	2	—	—	—	—	—
Hampton Institute	5	1	0	—	—	—	—	0	4	—	—	—	—	—
Hartford, U of	5	3	—	—	—	—	—	10	0	2	1	—	—	—
Hartwick C	—	29	11	24	—	—	—	8	22	1	—	—	—	—
Harvard U	12	0	—	—	—	—	—	—	—	—	—	—	—	—
Harvey Mudd C	4	13	—	—	—	—	—	17	49	15	24	78	6	2
Haverford C	15	7	2	3	—	—	—	10	13	0	0	—	—	—
Hawaii, U of	3	6	—	—	—	—	—	40	0	8	36	111	53	16
Hiram C	3	9	—	—	—	—	—	—	—	—	—	—	—	—
Hobart & William Smith C	2	4	—	—	—	—	—	15	5	13	11	56	4	4
Hofstra U	0	1	—	—	—	—	—	0	5	—	—	—	—	—
Hollins C	24	13	—	—	—	—	—	1	2	3	—	—	—	—
Holly Cross, C of the	14	18	—	—	—	—	—	1	2	0	3	—	—	—
Hope C	13	3	11	15	44	53	6	8	1	—	—	—	—	—
Houston, U of	3	25	5	3	19	0	—	10	0	—	—	—	—	—
Howard U	3	10	—	—	—	—	—	11	4	—	—	—	—	—
Humboldt State U	4	2	0	—	—	—	—	28	38	3	6	—	—	—
Idaho State U	6	2	1	2	17	7	1	0	81	0	0	—	—	—
Idaho, U of	9	0	—	—	—	—	—	19	15	10	24	76	13	4
Illinois Benedictine C	1	0	2	2	46	26	4	21	0	5	0	101	5	0
Illinois Institute of Tech	55	2	8	—	—	—	—	—	—	—	—	—	—	—
Illinois State U	11	29	23	7	40	7	0	53	0	35	21	154	20	4
Illinois, U of	69	70	14	52	105	21	8	12	7	—	—	—	—	—
Chicago	3	2	—	—	—	—	—	1	6	—	—	—	—	—
Urbana-Champaign	6	0	3	—	—	—	—	1	11	1	—	—	—	—
Illinois Wesleyan U	42	93	11	33	—	—	—	0	7	0	—	—	—	—
Indiana State U	14	10	5	—	—	—	—	2	6	—	—	—	—	—
Indiana U	2	4	—	—	—	—	—	2	5	—	—	—	—	—
Bloomington	6	4	—	—	—	—	—	4	16	—	—	—	—	—
South Bend	1	28	7	—	—	—	—	26	0	6	30	134	12	15
Indiana U of Pennsylvania	11	5	12	31	72	11	5	15	8	3	—	—	—	—
Indiana U-Purdue U	10	0	10	6	14	8	2	0	10	—	—	—	—	—
Fort Wayne	7	5	—	—	—	—	—	1	2	0	2	55	4	0
Indianapolis	2	4	3	—	—	—	—	4	9	1	3	24	2	1
Iowa State U	5	9	—	—	—	—	—	—	—	—	—	—	—	—
Iowa, U of	3	15	2	—	—	—	—	12	14	5	3	57	8	1
Ithaca C	—	—	—	—	—	—	—	5	13	2	2	—	—	—
Jackson State U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
James Madison U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
John Carroll C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Johns Hopkins U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Junata C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kalamazoo C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kansas State U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kansas, U of	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kean C of New Jersey	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kearney State C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kent State U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky, U of	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kenyon C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
King's C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Knox C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lafayette C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lake Forest C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lamar U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
La Salle C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lawrence Institute of Tech	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lawrence U ^c	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lebanon Valley C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lehigh U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Le Moyne C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lincoln U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Long Island U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn Campus	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C. W. Post C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Loras C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisiana State U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Baton Rouge	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Shreveport	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisiana Tech U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisville, U of	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lowell, U of	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Loyola C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Loyola Marymount U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Loyola U in New Orleans	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Loyola U of Chicago	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Luther C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Macalester C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Maine, U of	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Manhattan C ^d	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Manhattanville C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mankato State U	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Marietta C	—	—	—	—	—	—	—	—	—	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified		M.S.	Ph.D.	B.S.	M.S.	Ph.D.
	Yes	No					
Rolla	10	0	5	0	82	17	2
St. Louis	9	12	5	4	—	—	—
Missouri Western State C	0	1	—	—	—	—	—
Monmouth C (Illinois)	1	10	—	—	—	—	—
Monmouth C (New Jersey) ^a	—	—	—	—	—	—	—
Montana C of Mineral Science & Tech	1	2	1	—	—	—	—
Montana State U	8	5	4	5	59	5	1
Montana, U of	7	4	4	0	—	—	—
Montclair State C	2	12	1	—	—	—	—
Moorhead State U	4	2	—	—	—	—	—
Moravian C	5	4	—	—	—	—	—
Morehouse C ¹	8	8	7	1	—	—	—
Morgan State U	3	5	—	—	—	—	—
Mount Holyoke C	2	8	3	0	—	—	—
Mount Saint Vincent, C of ^d	0	1	—	—	—	—	—
Muhlenberg C	0	25	—	—	—	—	—
Murray State U	3	14	2	—	—	—	—
Muskingum C	5	6	—	—	—	—	—
Nebraska, U of	—	—	—	—	—	—	—
Lincoln	8	8	2	10	22	4	—
Omaha	8	6	—	—	—	—	—
Nebraska Wesleyan U	1	3	—	—	—	—	—
Nevada, U of	—	—	—	—	—	—	—
Las Vegas	1	4	—	—	—	—	—
Reno	6	4	2	3	—	—	—
New Hampshire, U of	5	9	5	2	38	4	0
New Jersey Institute of Tech ^b	—	—	—	—	92	9	5
New Mexico Highlands U	0	2	2	—	—	—	—
New Mexico Institute of Mining & Tech	10	0	9	—	—	—	—
New Mexico State U	6	9	11	5	28	7	—
New Mexico, U of	6	2	3	8	a	—	—
New Orleans, U of	4	10	1	6	—	—	—
New York U	12	21	19	11	—	—	—
Niagara U	4	7	—	—	—	—	—
North Alabama, U of	2	8	—	—	—	—	—
North Carolina A&T State U	7	0	4	—	—	—	—
North Carolina Central U	2	9	2	—	—	—	—
North Carolina State U	20	10	2	8	132	22	7
North Carolina, U of	—	—	—	—	—	—	—
Asheville	1	3	—	—	—	—	—
Chapel Hill	39	90	12	25	—	—	—
Charlotte	1	4	4	—	—	—	—
Greensboro	7	6	3	—	—	—	—
Wilmington	3	11	—	—	—	—	—
North Dakota State U	4	15	5	2	—	—	—
North Dakota, U of	0	3	3	2	23	9	—
North Texas State U	11	7	9	4	—	—	—
Northeast Louisiana U	3	1	4	—	—	—	—
Northeastern Illinois U ^a	—	—	—	—	—	—	—
Northeastern U	7	0	9	7	a	—	—
Northern Arizona U	4	23	3	—	—	—	—
Northern Colorado, U of	2	6	0	0	—	—	—
Northern Illinois U	6	12	8	5	—	—	—
Northern Iowa, U of	5	20	0	—	—	—	—
Northern Kentucky U	4	4	—	—	—	—	—
Northern Michigan U	0	7	0	—	—	—	—
Northwest Missouri State U	4	3	—	—	—	—	—
Northwestern State U of Louisiana	0	1	—	—	—	—	—
Northwestern U	11	17	32	17	47	19	12
Norwich U	0	0	—	—	—	—	—
Notre Dame, U of	7	11	4	10	65	8	2
Oakland U	11	3	0	—	—	—	—
Oberlin C	0	28	—	—	—	—	—
Occidental C	8	7	—	—	—	—	—
Ohio Northern U	2	4	—	—	—	—	—
Ohio State U	28	0	9	27	86	29	3
Ohio U	6	5	5	4	24	7	0
Ohio Wesleyan U	0	6	—	—	—	—	—
Oklahoma State U	7	7	2	7	42	9	6
Oklahoma, U of	12	30	9	2	72	13	3
Old Dominion U	8	3	9	—	—	—	—
Oregon State U	8	0	4	8	45	4	0
Oregon, U of	10	24	7	12	—	—	—
Pace U	1	4	—	—	—	—	—
Pacific Lutheran U	5	9	—	—	—	—	—
Pacific, U of	4	12	1	0	—	—	—
Pennsylvania State U	14	12	4	38	178	19	3
Pennsylvania, U of	11	33	3	21	65	15	8

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified		M.S.	Ph.D.	B.S.	M.S.	Ph.D.
	Yes	No					
Philadelphia C of Pharmacy & Science	9	0	4	2	—	—	—
Philadelphia C of Textiles & Science	1	0	—	—	—	—	—
Pittsburg State U	2	3	2	—	—	—	—
Pittsburgh, U of	8	71	16	12	56	11	1
Polytechnic Institute of New York	3	0	6	11	45	12	6
Pomona C	7	7	—	—	—	—	—
Portland State U	1	11	3	2	—	—	—
Pratt Institute ^b	—	—	—	—	12	—	—
Princeton U	9	11	18	19	23	6	8
Providence U	7	4	0	0	—	—	—
Puerto Rico, U of	—	—	—	—	—	—	—
Mayaguez	21	0	2	—	69	3	—
Rio Piedras	21	33	2	4	—	—	—
Puget Sound, U of	8	0	—	—	—	—	—
Purdue U	34	16	15	30	164	15	15
Purdue U Calumet	1	4	—	—	—	—	—
Randolph-Macon Woman's C	1	2	—	—	—	—	—
Redlands, U of	1	1	—	—	—	—	—
Reed C	10	3	—	—	—	—	—
Regis C	2	5	—	—	—	—	—
Rensselaer Polytechnic Institute	30	0	18	9	103	19	2
Rhodes C (formerly Southwestern, Memphis)	4	2	—	—	—	—	—
Rhode Island, U of	7	3	7	4	31	7	1
Rice U	3	1	10	10	38	11	6
Richmond, U of	0	11	0	—	—	—	—
Rider C	6	0	—	—	—	—	—
Ripon C	2	4	—	—	—	—	—
Roanoke C	5	3	—	—	—	—	—
Rochester Institute of Tech	10	18	11	—	—	—	—
Rochester, U of	10	7	28	11	50	11	2
Rollins C	1	0	—	—	—	—	—
Roosevelt U	5	0	7	—	—	—	—
Rose-Hulman Institute of Tech	7	0	—	—	a	—	—
Russell Sage C	5	0	—	—	—	—	—
Rutgers U	—	—	—	—	—	—	—
Camden C	2	7	—	—	—	—	—
New Brunswick	45	15	13	14	104	15	5
Newark C of Arts & Sciences	14	14	3	6	—	—	—
Saginaw Valley State C	1	11	—	—	—	—	—
St. Anselm C	5	3	—	—	—	—	—
St. Catherine, C of	2	4	—	—	—	—	—
St. Cloud State U	4	4	—	—	—	—	—
St. John Fisher C	4	1	—	—	—	—	—
St. John's U	10	1	2	—	—	—	—
St. John's U/C of St. Benedict ^c	—	—	—	—	—	—	—
St. Joseph C	3	2	6	—	—	—	—
St. Joseph's U	3	18	7	—	—	—	—
St. Lawrence U	7	18	—	—	—	—	—
St. Louis U	12	31	2	—	—	—	—
St. Mary's C	2	12	—	—	—	—	—
St. Michael's C	0	3	—	—	—	—	—
St. Olaf C	6	49	—	—	—	—	—
St. Peter's C	3	6	—	—	—	—	—
St. Thomas, C of	4	6	—	—	—	—	—
Salem State C	2	0	—	—	—	—	—
Sam Houston State U	9	1	4	—	—	—	—
San Diego State U	16	2	10	2	—	—	—
San Francisco State U	5	29	4	—	—	—	—
San Francisco, U of	3	7	1	—	—	—	—
Sangamon State U	1	1	—	—	—	—	—
San Jose State U	27	10	9	—	17	7	—
Santa Clara, U of	3	9	—	—	—	—	—
Scranton, U of	11	12	17	—	—	—	—
Seattle U	1	10	—	—	—	—	—
Seton Hall U	6	3	11	6	—	—	—
Shippensburg U	8	3	1	—	—	—	—
Siena C	7	2	—	—	—	—	—
Simmons C	5	4	—	—	—	—	—
Skidmore C	4	15	—	—	—	—	—
Smith C	9	0	1	0	—	—	—
Sonoma State U	1	9	—	—	—	—	—
South Carolina, U of	6	16	2	18	42	7	0
South Dakota School of Mines & Tech	8	0	4	—	38	9	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified		M.S.	Ph.D.			
	Yes	No			B.S.	M.S.	Ph.D.
South Dakota State U	4	19	3	—	—	—	—
South Dakota, U of	6	9	0	—	—	—	—
South Florida, U of	13	66	2	4	48	4	0
Southeast Missouri State U	0	7	—	—	—	—	—
Southeastern Louisiana U	0	3	—	—	—	—	—
Southeastern Massachusetts U	8	2	0	—	—	—	—
Southern California, U of	13	9	6	14	a	—	—
Southern Colorado U	1	6	—	—	—	—	—
Southern Illinois U	—	—	—	—	—	—	—
Carbondale	5	13	3	3	—	—	—
Edwardsville	13	3	2	—	—	—	—
Southern Methodist U	7	12	1	—	—	—	—
Southern Mississippi, U of	1	12	1	3	—	—	—
Southern Oregon State C	2	7	—	—	—	—	—
Southern U & A&M C	8	0	0	—	—	—	—
Southwest Missouri State U	5	21	—	—	—	—	—
Southwest State U	4	5	—	—	—	—	—
Southwest Texas State U	20	4	0	—	—	—	—
Southwestern Louisiana, U of	0	16	2	—	a	—	—
Southwestern Oklahoma State U	7	2	—	—	—	—	—
Stanford U	12	19	2	15	34	36	9
State U of New York	—	—	—	—	—	—	—
Albany	30	1	2	3	—	—	—
Binghamton	11	25	10	5	—	—	—
Buffalo	19	9	5	7	93	23	5
Stony Brook	20	37	3	17	—	—	—
C at Brockport	6	1	—	—	—	—	—
C at Buffalo	3	7	2	—	—	—	—
C at Cortland	3	6	—	—	—	—	—
C at Fredonia	9	2	4	—	—	—	—
C at Geneseo	8	2	0	—	—	—	—
C at New Paltz	7	4	4	—	—	—	—
C at Oneonta	1	25	0	—	—	—	—
C at Oswego	16	4	4	—	—	—	—
C at Plattsburgh	8	20	1	—	—	—	—
C at Potsdam	0	12	—	—	—	—	—
Stephen F. Austin State U	4	3	1	—	—	—	—
Stetson U	3	5	—	—	—	—	—
Stevens Institute of Tech	9	0	9	2	—	—	—
Suffolk U	2	3	—	—	—	—	—
Susquehanna U	1	7	—	—	—	—	—
Swarthmore C	3	10	—	—	—	—	—
Syracuse U	15	5	4	5	a	—	—
Temple U	7	4	3	4	—	—	—
Tennessee Technological U	3	22	2	—	29	8	0
Tennessee, U of	—	—	—	—	—	—	—
Knoxville	3	23	6	9	85	17	9
Martin	1	5	—	—	—	—	—
Chattanooga	13	7	—	—	—	—	—
Texas A&I U	6	0	4	—	a	—	—
Texas A&M U	16	11	10	35	139	17	2
Texas Christian U	3	9	0	3	—	—	—
Texas Southern U	21	0	6	—	—	—	—
Texas Technological U	14	7	7	9	43	11	1
Texas, U of	—	—	—	—	—	—	—
Arlington	10	9	1	2	—	—	—
Austin	50	0	13	16	101	28	6
Dallas	6	0	2	—	—	—	—
El Paso	6	0	10	—	—	—	—
Texas Woman's U	1	2	2	0	—	—	—
Thiel C	4	4	—	—	—	—	—
Thomas More C	1	1	—	—	—	—	—
Toledo, U of	5	9	0	0	24	4	0
Towson State U	3	7	—	—	—	—	—
Trenton State C	15	0	—	—	—	—	—
Trinity C	12	4	0	—	—	—	—
Trinity U	6	6	0	—	—	—	—
Tri-State U ^b	—	—	—	—	16	—	—
Tufts U	2	19	1	4	33	3	0
Tulane U of Louisiana	2	12	1	2	33	8	0
Tulsa, U of	2	0	—	—	33	12	2
Tuskegee Institute	0	2	3	—	f	—	—
Union C	7	12	—	—	—	—	—
U.S. Air Force Academy	12	1	—	—	—	—	—
U.S. Naval Academy	18	1	—	—	—	—	—
Ursinus C	4	20	—	—	—	—	—
Utah State U	9	0	4	5	—	—	—
Utah, U of	6	27	3	8	a	—	—
Valparaiso U	3	33	—	—	—	—	—
Vanderbilt U	1	18	3	4	44	5	0

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified		M.S.	Ph.D.			
	Yes	No			B.S.	M.S.	Ph.D.
Vassar C	2	6	0	—	—	—	—
Vermont, U of	19	0	0	5	—	—	—
Villanova U	11	0	8	5	30	6	—
Virginia Commonwealth U	9	11	5	2	—	—	—
Virginia Military Institute	12	0	—	—	—	—	—
Virginia Polytechnic Institute & State U	27	10	5	12	77	12	2
Virginia, U of	11	72	5	10	41	26	2
Wabash C	10	5	—	—	—	—	—
Wagner C	0	3	—	—	—	—	—
Wake Forest U	5	16	0	0	—	—	—
Washburn U of Topeka	0	4	—	—	—	—	—
Washington C	2	0	—	—	—	—	—
Washington & Jefferson C	2	29	—	—	—	—	—
Washington & Lee U	1	13	—	—	—	—	—
Washington State U	7	10	7	16	34	13	0
Washington U	5	12	8	10	69	15	2
Washington, U of	31	26	16	11	80	12	4
Wayne State U	20	14	6	15	42	20	1
Waynesburg C	5	2	—	—	—	—	—
Weber State C	6	4	—	—	—	—	—
Wellesley C	5	31	—	—	—	—	—
Wesleyan U	3	21	1	5	—	—	—
West Chester U	6	12	2	—	—	—	—
West Florida, U of	13	2	—	—	—	—	—
West Texas State U	1	13	0	—	—	—	—
West Virginia Institute of Tech	2	1	—	—	20	0	—
West Virginia State C	3	7	—	—	—	—	—
West Virginia U	10	39	9	4	41	7	0
Western Illinois U	18	5	2	—	—	—	—
Western Kentucky U	9	18	8	—	—	—	—
Western Maryland C	1	11	—	—	—	—	—
Western Michigan U	3	12	4	1	—	—	—
Western New England C	5	0	—	—	—	—	—
Western Washington U	13	10	3	—	—	—	—
Westminster C	0	8	—	—	—	—	—
Wheaton C (Illinois)	3	13	—	—	—	—	—
Wheaton C (Massachusetts)	7	6	—	—	—	—	—
Wheeling C	0	1	—	—	—	—	—
Whitman C	6	10	—	—	—	—	—
Whittier C	1	2	—	—	—	—	—
Wichita State U	6	11	6	1	—	—	—
Widener U	1	0	—	—	—	—	—
Wilkes C	4	3	—	—	—	—	—
Willamette U	2	10	—	—	—	—	—
William Paterson C of New Jersey	0	2	—	—	—	—	—
William & Mary, C of	18	5	2	—	—	—	—
Williams C	1	35	—	—	—	—	—
Wisconsin, U of	—	—	—	—	—	—	—
Eau Claire	11	5	—	—	—	—	—
Green Bay	0	5	—	—	—	—	—
La Crosse	2	4	—	—	—	—	—
Madison	16	33	8	27	131	13	7
Milwaukee	3	12	8	4	—	—	—
Oshkosh	10	3	3	—	—	—	—
Parkside	5	10	—	—	—	—	—
Platteville	1	2	—	—	—	—	—
River Falls	6	12	—	—	—	—	—
Stevens Point	4	11	—	—	—	—	—
Superior	2	2	—	—	—	—	—
Wittenberg U	3	5	—	—	—	—	—
Wooster, C of	3	25	—	—	—	—	—
Worcester Polytechnic Institute	2	4	0	0	66	7	2
Wright State U	20	8	9	—	—	—	—
Wyoming, U of	4	2	2	7	20	4	0
Xavier U	3	9	1	—	—	—	—
Xavier U of Louisiana	2	25	—	—	—	—	—
Yale U	8	1	24	23	a	—	—
Youngstown State U	3	33	3	—	32	—	—
TOTALS	4201	5618	1637	1777	6866	1436	357

a Data not submitted. b Listed on basis of accreditation by AIChE-ABET. c Master's and Ph.D. degrees given by the Institute of Paper Chemistry. d The chemistry programs at Mount Saint Vincent College and Manhattan College are integrated into a combined department with all instruction in chemistry located at Manhattan College. e Added in 1984. f Master's degrees given by Atlanta University. Note: For brevity, B.S. and M.S. are used to denote all bachelor's and master's degrees, respectively, in each column.

APRIL 29, 1985

CHEMICAL & ENGINEERING

NEWS

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SRI ACQUISITIONS

COSMETICS

Art yielding to science in formulations
Page 19

News of the Week

■ Post-Bhopal safety concerns prompt new Center for Chemical Plant Safety. **Page 6**

■ Union Carbide stands up to Indian criticism of settlement for Bhopal victims. **Page 7**

■ Chemical earnings apparently were down at least 26% in first quarter from year ago. **Page 7**

■ Allied has obtained license to make biaxially oriented nylon-6 film for food packaging. **Page 8**

■ NAS elects 60 new members, bringing total academy membership to 1453. **Page 8**

Cover: Workman prepares pigments for cosmetics such as lipstick. Photo courtesy of Avon Products

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Business

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Government

Study for Congress finds many deficiencies in the way government protects workers from illness and injury. **Page 14**

Technology

Newly developed column packing materials for high-performance liquid chromatography simplify sample preparation. **Page 47**

Education

Workshop encourages women to pursue chemistry careers and answers questions peculiar to women chemists. **Page 48**

Books

"The Financial Side of Industrial Research Management" by Lynn Ellis centers more on engineering R&D. **Page 49**



Product Report

Cosmetics are switching to the realm of the scientist as science replaces art in formulations. **Page 19**

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LETTERS

Fighting with like weapons

SIR: Reference is to your article on the Pentagon need for binary chemical deterrent (March 18, page 13).

In what can only be considered typical Pentagon mentality, Thomas Welch "argued that the U.S. does not have a chemical weapon capability to deter the Soviets from using such weapons against U.S. forces or those of its allies." How incredibly asinine. By whose definition must wars be fought with like weapons? Can't we simply look at our arsenal on its own merit, decide if it is adequate to protect us, and then use whatever means necessary to respond to anyone who attacks us?

God help us if the Soviets ever aim a tidilywink in our direction, for obviously the Pentagon will require a bigger and better one.

James Crawford, Terre Haute, Ind.

SIR: The argument that we must build more chemical weapons in order to ban such arms is mind-boggling. In the March 18 C&EN report of the Pentagon's request for more chemical weapons we have another example of how language and ideas can be twisted into virtual meaninglessness. George Orwell warned us of this.

It is my firm conviction we should continue the moratorium on chemical weapons production. I also believe it is possible to hold a rational debate over the differences between my position and that of the Pentagon. However, their current use of NEWSPEAK both dismays and puzzles me. I don't know whether to snicker or to cry.

Gerald Bakker, Holland, Mich.

The search for knowledge

SIR: Winslow Hartford has issued a call for independence of secular knowledge from sectarian "distortions" imposed on it by religious beliefs (C&EN, Feb. 11, page 2). This appeal misses the point entirely. The search for knowledge is driven by one ultimate goal—understanding the universe.

All knowledge, religious and so-called secular knowledge, is bound up in this same search. Assuming (as most religious people do) that there is a God who created the universe, the obvious question is whether an understanding of the nature and character of this God would provide knowledge which could be used in all areas of life.

Going further and assuming the truth of our assumption, were we able to speak directly with this God, could we find the answers to all the unanswered religious as well as scientific

questions we now have? Therefore, for the majority of people who believe in a God (as Hartford states by assuming that only a few of us are truly atheists), there can be no separation of secular knowledge from religious knowledge, for they are one and the same. To separate the two in an artificial distinction is to already assume the two are different. To a religious man the distinction is a non sequitur.

What Hartford is really suggesting is that anyone can believe in God provided they do not claim that this God has anything to say about secular (translate human) knowledge. In other words, God doesn't care how the universe runs and neither should the "distorted" sectarians. The absurdity of this position should be clear to anyone, even someone so obviously anti-God as Hartford. And it is further heartening to see that politicians across the land are protecting us from such narrow-minded impositions upon our knowledge by "selfishly introducing these issues into their campaigns" and from such self-proclaimed experts who are "better equipped" to handle these issues than the people's representatives.

Joseph and Richard Luciana
Oakmont, Pa.

No political views in C&EN

SIR: I am shocked and saddened that you are allowing our publication to become a platform for government political views (C&EN, March 18, Editor's Page, "Advice to Scientists" by Secretary Shultz). Scientists are the conscience of the nation and are more concerned with human interest than a politician would be. Indeed, the core issues here are both political and moral. The morality of these vital issues, such as the imminent dangers of nuclear war to humanity, are more understood by scientists than by any political leader. If the scientists do not speak out, who will?

I doubt if the State Department allows any scientists' views to be published in any of its publications.

Rafi M. Salem, Danville, Calif.

Corrections

• April 8, page 17: In the table, the third column from the left lists quantities of leaded gasoline demand, rather than unleaded.

• April 22, page 75: There will be no on-site registration for the luncheons or banquet at the MARM meeting.



Cosmetics

**Science
is replacing
art in formulations**

Patricia L. Layman, C&EN London

In the world of cosmetics and toiletries, success rests on advertising, marketing, glamor, razzle-dazzle. For the world of raw materials for personal-care products, however, the emphasis is increasingly on science. What was once an art in making and formulating is becoming more and more sophisticated science. Raw-material suppliers that recognize that change and move with it will be the ones to ride to the top in the coming years.

Certainly the market is large enough to attract suppliers. Estimates

are difficult to come by, but the 1985 market for raw materials for cosmetics and toiletries probably will be about 2 billion lb in the U.S. alone. That would be worth about \$1.2 billion at the manufacturers' level.

All that for a U.S. market for cosmetics and toiletries that likely will ring up manufacturers' sales this year of more than \$11 billion. The U.S. accounts for about one third of the total worldwide market for cosmetics and toiletries of more than \$32 billion, according to one estimate; if the same proportions hold true, the worldwide market for raw materials for this industry is more than 5 bil-

lion lb of a variety of compounds, worth \$3.4 billion.

Even though growth has slowed over the past few years and even though the cosmetics and toiletries industry has discovered that, contrary to conventional wisdom, it is not recession-resistant, it is still an industry well worth supplying.

Overall growth in demand is expected to be relatively slow, forecasts SRI International, in a new report on cosmetic chemicals, part of a specialty chemicals update program. Total growth of cosmetics and toiletries has averaged 1 to 2% per year for the past five years, considerably less than the

U.S. is largest western market for personal-care products

	1983, \$ millions of manufacturers' level				
	U.S.	West Germany	France	Italy	U.K.
COSMETICS	\$ 6,788	\$ 982	\$1092	\$ 852	\$ 491
Skin care	2,544	472	330	230	108
Fragrances	2,332	210	327	142	126
Makeup	1,270	200	187	163	125
Men's lines	840	100	165	147	72
TOILETRIES	\$ 3,114	\$ 1036	\$ 779	\$ 624	\$ 666
Hair care	1,590	475	352	236	275
Oral hygiene	954	227	115	115	112
Deodorants	740	140	65	107	76
Bath products	530	243	146	166	200
TOTAL	\$10,900	\$2067	\$1869	\$1386	\$1160

Source: Industry, CAEN estimates

growth experienced during the 1970s.

More than 1000 chemical compounds are employed routinely as cosmetic ingredients, and many more are used less frequently or only in certain countries. Of all of these, cosmetic chemicals such as silicone emollients, sunscreen actives, and quaternized polymers used in hair conditioners are expected to maintain above average growth. However, ingredients such as dental polishing agents, which are formulated into end products already widely used, probably will grow at below average rates.

A steady stream of new products

being developed by the cosmetics and toiletries industries likely will offer many opportunities for introducing new and improved chemicals, SRI says—although researchers in some supplier companies predict that because the volumes are relatively quite small, the chemicals won't have been developed exclusively for cosmetics and toiletries. Of particular interest are ingredients whose properties or origin can be used by cosmetic companies as the basis of new advertising or merchandising campaigns. And SRI predicts it is unlikely that there will be any dramatic or traumatic regulatory developments affecting the industry, such as the virtual elimination of chlorofluorocarbon aerosols in the U.S. in the 1970s.

The three largest markets for cosmetics materials—the U.S., Western Europe, and Japan—are considered highly mature, with slow growth. Higher growth is expected in Asian countries and in Latin America, provided economic stability is achieved in Latin America.

For the cosmetics and toiletries industry itself, there are an estimated 3000 manufacturers worldwide. However, 25 multinational manufacturers—giants such as Avon, L'Oreal, Procter & Gamble, Henkel, Unilever, Revlon, and Beecham—account for about half the business.

The raw materials side of the business is in striking contrast to that, however. One of the first surveys on this industry, by consultants Charles H. Kline & Co. in 1979, pointed out that more than 100 companies mar-

keted cosmetic raw materials in the U.S., and no one company had a dominant position. The sales figures the study quoted then have changed, of course, but the structure itself hasn't changed all that much.

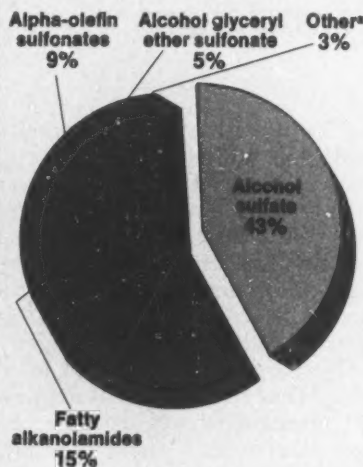
Perhaps most surprising, however, is that the most active suppliers to the industry are not the largest chemical companies. To be sure, they are frequently there, but generally with just one or two items they concentrate on. Union Carbide, for example, supplies its Polymer JR for conditioning products, and Du Pont and Phillips supply aerosol propellants. Far more important to the cosmetics industry are the smaller companies that concentrate on the entire industry, such as International Flavors & Fragrances, Croda, Onyx, Mona, GAF, Stepan Chemical, and Witco Chemical.

Even those subsidiaries of large companies that pay particular attention to the cosmetics and toiletries industry have tended to keep their identities as independent, smaller operations—ICI Americas, for example, to whom cosmetic raw materials are far more important than to its U.K. parent; Lonza, with a similar relation to its Swiss parent; Emery Chemicals, part of National Distillers & Chemical; Amerchol, part of CPC International.

Quite rare, in fact, are the companies for whom supplying the raw materials for cosmetics and toiletries is as important for both parent and subsidiary or division. Henkel in West Germany and its Minneapolis; Akzo in the Netherlands and in Chicago; BASF in West Germany and BASF Wyandotte in Parsippany, N.J., are examples.

Whoever is doing the supplying, however, the company is aiming at an industry with two distinct parts—commodity items and specialties. Fragrance compounds and surfactants account for roughly half the sales volume in dollars of cosmetic and toiletry raw materials. The rest of the market is then taken up with organic commodities such as ethanol and glycerin, and semicommodities such as sorbitol; organic specialties such as cellulose derivatives, sunscreen agents, and proteins; inorganic chemicals, including dentifrice polishing agents, nacreous pigments, and antiperspirant salts;

Alcohol sulfate dominates cosmetics surfactants



1984 total = 169 million tons

a Includes alcohol ethoxylates, fatty amine oxides.
Source: CAEN estimates

These are the primary groups of cosmetics' raw materials

Emollients

Esters—natural, synthetic
Ethers
Lanolin
Fatty alcohols
Hydrocarbons
Silicones
Various water-soluble emollients
Surfactants
Detergents, emulsifiers, solubilizers
Solvents
Ethanol

Thickeners

Modifying agents—for example, cellulose derivatives
Clays—natural, synthetic
Humectants
Moisturizing agents, conditioners, sterols, proteins
Preservatives
Perfumes/colors/flavors
Special-function active chemicals
Aluminum chlorhydrate, sunscreens

fatty chemicals, such as lanolin and its derivatives, and fatty acids and derivatives; biocides; and petroleum products, particularly mineral oil and petrolatum. Propellants are becoming increasingly important once

again, as marketers see a resurgence in aerosol cosmetics and toiletries.

Those materials serve a variety of functions, from forming emulsions, thickening, and so on within the formulation, to a host of roles when

the product is applied—giving emolliency, protecting, coloring, and the like.

Many of the materials used are of natural origin. That leaves them vulnerable to the vagaries of crop fluctuations, weather effects, and such—but it is also frequently a plus for marketers eager to cater to consumers smitten by the concept of "natural." Sometimes that's a matter of what you call it. Is labeling that proclaims "soy protein" unappealing? Perhaps "vegetable protein" or "phyto protein" would be more sales-evocative, as one supplier puts it. Silk protein, palm oil, chamomile extract—all are appealing terms for marketers to put on labels.

The opportunities for suppliers of natural-based raw materials for cosmetics and toiletries helped encourage the National Renderers Associa-

Typical applications of the major groups of cosmetics' raw materials

	Emollients	Surfactants	Solvents	Thickeners	Humectants	Preservatives	Perfumes/colors/flavors	Special-function active chemicals
Perfumes, colognes		●					●	
Dusting powder, talc	●							
Cream perfume	●			●	●			
Bath salts	●							
Bath oils	●	●					●	
Lipstick	●						●	
Lip salves	●							
Nail enamels	●		●				●	
Blushers	●	●		●		●	●	
Eye makeup	●	●	●	●		●	●	
Foundation	●	●		●		●	●	
Moisturizers, creams, lotions	●	●		●		●		
Astringents, tonics	●		●		●	●	●	
Treatment products	●	●		●		●	●	●
Sun preparations	●	●		●		●	●	●
After shave, colognes		●					●	
Preshaves	●						●	
Talc	●							
Deodorants, antiperspirants	●	●		●			●	●

	Emollients	Surfactants	Solvents	Thickeners	Humectants	Preservatives	Perfumes/colors/flavors	Special-function active chemicals
Grooming creams	●	●					●	
Oils	●						●	
Hair tonics	●						●	
Hair sprays	●						●	
Setting lotions	●			●			●	
Hair colorants	●	●	●				●	
Bleaches	●	●					●	
Permanent waves	●	●					●	
Conditioners		●					●	●
Shampoo		●					●	
Toothpaste		●		●	●		●	●
Mouthwashes		●					●	●
Denture products		●					●	●
Aerosol deodorants	●	●		●			●	●
Roll-on deodorants	●			●			●	●
Stick deodorants	●						●	●

● Used in product

○ Can be used in product

HLB values can predict performance...

Water solubility	HLB (hydrophilic lipophile balance) range
No dispersibility in water	1-4
Poor dispersion	3-6
Milky dispersion after agitation	6-8
Stable milky dispersion	8-10
Translucent to clear dispersion	10-13
Clear solution	13+

...for these kinds of applications

Application or use	Suggested HLB range
Antifoaming	
Alcohol systems	1-3
Aqueous solution or dispersion	1-8
Bath oils	
Spreading, mineral oil	9
Spreading, oleyl alcohol	11
Blooming, dispersible	5
Soluble	10-17
Blending immiscible oils	1-2
Clear gels (mineral oil)	10-12
Creams, emulsions, and lotions	
Creams with acid salts	11-17
Creams, mineral oil-base wax, oil in water	
Creams, petrolatum or mineral oil, oil in water	3-16
Creams, stearic acid, oil in water	9-15
Creams, fatty alcohol, oil in water	9-16
Creams and lotions, water in oil	3-6
Lotions, oil in water	6-18
Dyes	
Oil-soluble into water	12-16
Water-soluble into oil	3-6
Emulsions, oil in water	
Oils, mineral or petrolatum	7-12
Oils, vegetable	6-12
Wax, paraffin	9-12
Emulsions, water in oil	3-6
Petrolatum, washable	9-17
Solubilizing	
Flavor, vitamin oils	15
Essential oils, perfume	12-18

Source: ICI Americas

tion, of Des Plaines, Ill., to schedule an international symposium on natural-based cleaning agents and personal-care products in Marseille last week. Most of the symposium focused on the much larger soap and detergent industry. But at least some of the program pertained to cosmet-

ics and toiletries, discussing such topics as historic backgrounds and economics, new raw materials and products, recent developments in analytical techniques, and new developments in processing and manufacturing. The symposium also featured a trip to Grasse, near Marseille, the traditional capitol of essential oils, so critical to cosmetics and toiletries.

At the same time as the emphasis on natural, the cosmetics and toiletries industry is taking on more of a scientific aura. That fact was highlighted in a recent survey on the shampoo and conditioner segment of the industry, put out early this year by Packaged Facts consulting firm in New York City, and it is also valid for most other segments. There is, says the company, "simultaneous infatuation of Americans for two divergent product trends: natural and technological."

Shampoos and conditioners provide a wealth of examples of the divergence. There are shampoos and conditioners with such ingredients as aloe vera, jojoba, and henna, and a number of new entrants with chamomile as a key ingredient, or marketing emphasis. On the other hand, there are both new and existing products in the segment positioned "scientifically," points out Packaged Facts, with the promotion stressing that technology will care for the hair.

Each is a valid approach for marketers, depending upon to whom they wish to sell, and market targeting is becoming increasingly more precise. However, it now costs about \$6 million to introduce a new shampoo or conditioner, and 90% of the 200 or so new brands introduced each year fail on the marketplace. Marketers keep trying, however, lured on by hopes for several percentage points of a market now worth more than \$2 billion at retail level. At present, about two thirds of those sales are shampoos and the rest conditioners, but the latter will see faster growth. By 1994, Packaged Facts predicts, the two segments will be nearly equal in retail volume.

In many respects, that is not surprising. Because whether the job is done naturally or scientifically, the consumer is seeking ever more con-

ditioning, mild, and protective treatment from cosmetics and toiletries.

As one technical laboratory manager puts it, "Mildness is always a trend. It's not that the materials used now are irritating—they really aren't. But customers still want milder and milder products for their formulations." That has given a particular boost to amphoteric surfactants, the nonirritating surfactants used in baby shampoos. Mildness for children is one aspect of this, another is concern for frequent use. Mild surfactants, for example, won't scrub the hair squeaky clean if it is shampooed daily.

The search for mildness, and testing for nonirritancy of cosmetic raw materials, is one of the basic jobs for suppliers. The testing is relatively uncomplicated, and Draize eye tests probably cost about \$1000 per chemical. (Gaining complete information for a safety data sheet might run twice that; if a product is going to be absorbed into the body—for example, from a wound dressing—that requires a new drug application, and costs range from \$100,000 to \$150,000.)

Testing also brings the industry up against one of its most implacable foes: animal rights activists, who protest the use of live rabbits in the Draize test. The pressure from these groups has encouraged much research into alternative test methods, but none are completely successful as yet. Revlon, for one, is now in its fifth year of supporting alternative safety tests with research at Rockefeller University in New York City, as well as doing its own, in-house testing.

Earlier this year, British researchers at Leicester Polytechnic developed a technique for using bovine corneas to assess chemical irritancy. The method monitors opacity as a measure of irritant-induced damage. Bovine eyes are obtained from slaughterhouses, and the corneas are clamped into an acrylic holder that allows solution to be in contact with both surfaces of the cornea. The holder is placed inside an opacimeter, in which a beam of white light passes through the cornea to a photocell. A decrease in the incident light reaching the photocell allows measurement of opacity caused by the test substances.

Testing costs for new materials do add up in the long run, and suppliers agree that that is especially true for raw materials that have never been used in cosmetics and toiletries before, or have no close analogs that might give some hint as to what kinds of safety testing are needed.

In fact, one supplier somewhat gloomily predicts that because of the testing costs, and the relatively small size and payout from the personal-care industry, very few new materials will be developed especially for it. New materials, he adds, will come from the pharmaceutical industry if any potential cosmetics applications come to light.

That is not a new development. Two years ago, for example, consultants Frost & Sullivan pointed out the ramifications of that in a study on the European cosmetics and toiletries industry. "As the distinction between cosmetics and drugs blurs, research-based organizations that approach cosmetics and toiletries almost as over-the-counter drugs will prosper during the 1980s," the company said. On that basis, the study predicted that by 1990, companies

such as Beecham, Richardson-Vicks, and Elida-Gibbs would be the major marketers in Western Europe of personal-care products.

If that held in the U.S., it would give even more impetus to cosmetics houses, such as Revlon, that have a pharmaceutical arm, with the scientific side of pharmaceuticals becoming more important in R&D.

Until that development really takes hold, however, U.S. marketers of cosmetics and toiletries will go their merry way with product innovation and promotion. Industry observers agree that the U.S. market tends to react faster to new trends in the cosmetics and toiletries industry, and that when it does not actually introduce new products and concepts first, it frequently can carry the ball further.

A number of years ago, for example, an ordinary toilet soap called "Fa" appeared on the West German market, with a—for the times—high concentration of fresh, outdoors scent. American marketers liked the idea, came home and set about formulating their own highly scented soaps. That led to a proliferation of highly scented, decorative, and expensive soaps, the sort now found in fancy boutiques, department stores, and gift shops.

The same thing may be happening now with the latest star in the cosmetics and toiletries world—mousses. The premier definition of the French word "mousse" is "froth, foam; lather; whipped cream." Foam technology has been around for decades—aerosol shaving lathers have been the pre-eminent examples. (This oldest of "mousse" uses got a major boost in 1983 when several brands of gel lather were introduced to compete with S. C. Johnson's Edge.) And at one time, there were some small, and ultimately unsuccessful, attempts to use foam technology for other kinds of personal-care products.

But several years ago, European marketers, led by L'Oreal, introduced mousse hair-care products, and the concept took off. There are a number of advantages to the mousses. They aren't messy (important for a consumer coloring his or her hair, for example), and they give pinpoint application precision (no overspray

or runny liquids). Given the high proportion of air incorporated into them, the products are extremely light and fluffy.

The hair-care mousses also provide a functionally excellent combination of hold, with a setting resin, and combability, with a conditioning resin. It was new to the younger generation of consumers, who perhaps had never seen other, earlier attempts at foam products, and off it went.

In the U.S., moreover, when the mousses were introduced, they had the cachet of European (especially French) marketing, and they took off here, too. In fact, the market may be expanding in the U.S. even more rapidly than in Europe.

Some suppliers feel that the European market is being stifled because L'Oreal has such extensive patent coverage (the basic one, by one report, 100 pages long, and at least three more, covering variations and extensions of the technology) on use of combinations of cationic and anionic resins in foams.

"Cosmetics aren't normally too long-lived—certainly much less than a 17-year patent life," says one supplier. L'Oreal's patents have given it a jump on its competitors, but also have hindered development of the technology because it is stretched to meet its hair-care product requirements.

It is too early, some suppliers say, to predict interest in Europe for mousses for other kinds of products, including skin-care items, body lotions, suntan preparations, baby products, and so on. But in North America, new mousse products already have been introduced in test markets, with Canadian consumers having a number on the regular market. For instance, at least one marketer has introduced in Canada a product that suppliers believe is promising: a baby powder. It is sprayed as a foam on baby's bottom, where it dries to a powder. There is no powder in the air to cause coughing or sneezing, and no mess.

Meanwhile, suppliers are watching to see when mousses will find success in the Japanese market, where up until now they have been absent.

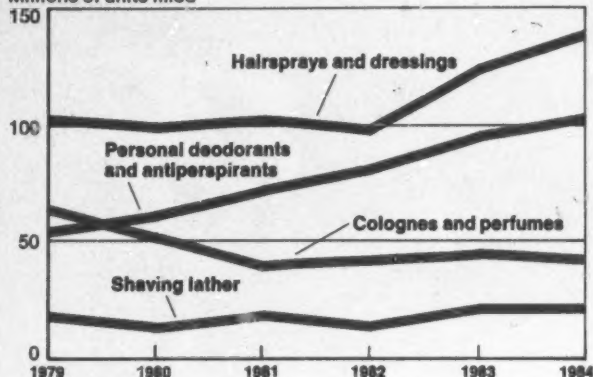
Suppliers wind up in a debate as to



Hair-care products account for largest share of western market for toiletries

Hair mousses have boosted U.K. aerosol sales ...

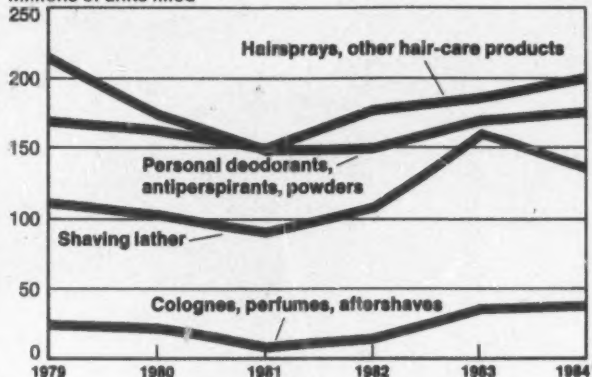
Millions of units filled



Source: British Aerosol Manufacturers' Association

... and may help U.S. personal-care aerosol market

Millions of units filled



a C&EN estimate. Source: Chemical Specialties Manufacturers' Association

whether mousses are a lasting phenomenon or a passing fad. Most, however, feel that products, not the packaging, tend to be a fad, and the mousse technology is really a method of packaging and delivery. The benefits are there, they believe, and this time around, foams will be here to stay, by whatever name.

That's good news for the aerosol industry, which already has been the prime beneficiary of the mousse movement sweeping the cosmetics and toiletries industry—much to the bemusement of industry marketers. After all, mousses are simply foams, and foam technology has been around for decades. Not long ago aerosol cosmetics and toiletries were having rough times. But it looks in-

creasingly as though the upturn that began haltingly in 1982 gained strength in 1983 and into last year, becoming a genuine growth phase. For suppliers to this industry, it can only be a matter of "It's about time."

A leading indicator of the renewed health of cosmetic and toiletry aerosols comes from the U.K. In 1983, aerosol production there hit record levels. And last week, the British Aerosol Manufacturers' Association released its 1984 report, which showed yet another record year for production. The major reason for the growth? The 12.4% increase in the category "hairsprays and dressings," which rose from 124.5 million units filled in 1983 to 140 million, to account for 22% of the total British aerosol market.

Other than the Scandinavian countries, however, Britain and the rest of Europe saw relatively little effect on their aerosol markets because of the controversy surrounding chlorofluorocarbon propellants. The controversy hit the U.S. hard, though, when it developed in 1973.

For U.S. aerosol marketers and suppliers, the term is still "recovery." The industry is back to growing, but it hasn't returned to the dizzy levels of 1973, when 2.9 billion aerosol units were filled. From those levels, production gradually tumbled, reaching a low of 2.16 billion units filled in 1980. Of those, 29% were personal products, and that category had slipped 17% from 1979 alone. In

1983, in the U.S., 2.28 billion aerosols were filled; of those, 33% were personal products. Production figures for 1984 won't be reported until next month by the Chemical Specialties Manufacturers' Association, but overall growth is expected to be about 5% from 1983. And much of that growth, as in Britain, will be coming from personal-care products in aerosols.

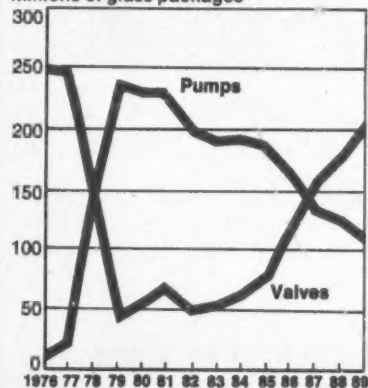
The CSMA "personal products" category includes a variety of sub-segments, including medicinals and pharmaceuticals (for example, vaporizers, burn treatments, and antiseptics) and "other" (such as suntan preps and depilatories). But the bulk of the category consists of hairsprays and other hair products; shaving lather; personal deodorants, antiperspirants, powders and deodorant colognes; and colognes, perfumes, and after-shave. Industry observers expect the 1984 figures to show growth for all these segments except for shaving lather.

It all seems to indicate, then, that the industry finally has begun to emerge from the shadows cast over it by the debate and controversy begun in the early 1970s over whether chlorofluorocarbon propellants could damage Earth's ozone layer. Banning the use of chlorofluorocarbon propellants resulted in a switchover to other aerosol propellants, primarily hydrocarbons.

And further changes in propellant systems also may mean new opportunities for aerosols. For example,

Valves may exceed pumps In U.S. fragrance aerosols

Millions of glass packages



Note: Includes imports. Source: Risdon Mfg. Co.

Ozone scare sent aerosol sales plummeting

When the controversy about chlorofluorocarbons and possible depletion of Earth's ozone layer arose early in the 1970s, it was seized upon by what one industry marketer calls "the new Calvinists, who were already pillorying aerosols as the symbol of the hedonistic, luxury-loving generation." With that campaign joining the scientific debate on atmospheric chemistry, the damage to the aerosol industry was perhaps inevitable.

In the U.S., the Environmental Protection Agency banned use of chlorofluorocarbon propellants, with only a very few exceptions. The Scandinavian countries (particularly Sweden and Norway) were similarly restrictive. The Danish representatives in the European Economic Community lobbied for severe restrictions on the use of chlorofluorocarbons, echoed by none-too-subtle pressure on European scientific and business communities by U.S. representatives.

"We were somewhat jaundiced by the pressure from the U.S.," says one European marketer. "It was very counterproductive. The U.S. environmentalists kept saying, 'We've got to be right, and you have to do this.' We resented that."

The EEC camps that wanted a ban on chlorofluorocarbons and those believing more research should be done first eventually compromised on a 30% reduction from the 1976 level of production of the two major aerosol propellants. That reduction, and an agreement never to expand capacity in the future,

affected the bulk of chlorofluorocarbons in Western Europe, which went mostly into aerosols, unlike in the U.S., where air conditioning is also an important, and unrestricted, end use for the two chemicals involved—CFC-11, trichlorodifluoromethane; and CFC-12, dichlorodifluoromethane. The result has been a decline of more than 50% in sales of the two compounds used for aerosols worldwide, according to the running data collected by the Fluorocarbon Program Panel of the Chemical Manufacturers' Association.

Meanwhile, hydrocarbon propellants, which had been gaining steadily in importance for aerosols in the U.S., became nearly all the market. That changeover was most significant for personal-care products, as hydrocar-

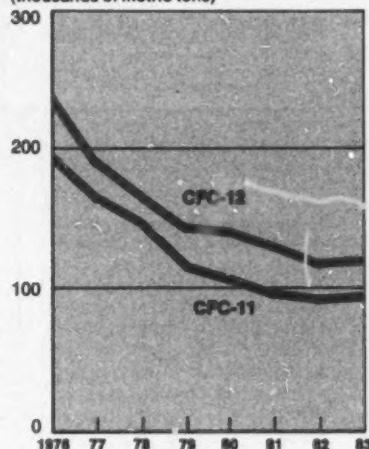
bons were already the most widely used propellants for such aerosol categories as household products and paints.

More ominous for the aerosol industry during that troubled decade, however, was that many marketers abandoned aerosols. They either dropped them out of their personal-care product lines altogether, or they relegated them to stepchild status, giving them no advertising support.

Very few marketers of cosmetics and toiletries attempted to explain in advertising that there had been a change of propellant to one not involved in any controversy. Indeed, on the few occasions when they did try to explain, there was controversy within the aerosol industry itself, where some people felt the industry should stand together—or fall together.

Although the debate is now more than a decade old, and it still has not been settled much to anyone's satisfaction, things are beginning to settle down. As one U.S. supplier notes, "For 10 years, the industry spent its time and money fighting regulations, coping with costs for switching over propellants, fighting warehousing battles, and so on, not spending them in labs for R&D or on advertising promotions. All those problems are in hand or mostly in hand now. And now marketers are beginning to advertise aerosols again. R&D labs are beginning to work on new concepts again. So the growth that will come will be from increased use of aerosols and from new products."

Global sales of aerosol chlorofluorocarbons (thousands of metric tons)



Source: Chemical Manufacturers Association

fragrances have proved the weakest market area for hydrocarbon propellants, with most marketers electing, instead, to use pump packages. Pumps aren't all that satisfactory, however. They are more expensive than aerosol packaging; they don't give a fine, continuous spray; and they introduce oxygen into the fragrance upon each use, which can degrade the fragrance oils.

The commercialization of new propellant systems—dimethyl ether, for example, or hydrochlorofluorocarbons (unrestricted because they are not perfluorinated) such as chlorodifluoromethane, 1,1-difluoro-

ethane, and 1,1,1-chlorodifluoroethane—may change this. U.S. industry observers say these new propellants are particularly interesting to European fragrance marketers eager to bring to the U.S. the same perfumes and colognes they sell in other areas of the world, without having to reformulate to cope with different propellants.

The possibilities for the new propellants have led to predictions by valve maker Risdon Manufacturing Co. that by 1986, the fragrance industry, which shifted from aerosols to pumps in 1977, will shift back. U.S. fragrance houses also will be impor-

tant to this move, of course, and suppliers are keeping an eye on new product introductions. There were high hopes late last year for the launch of a new Estée Lauder aerosol perfume, for example, and keen disappointment at its lack of major success. Chagrined suppliers say, however, that the experience was due to an uncharacteristic fumbling on Estée Lauder's part in dealing with the department store personnel who sell the fragrances, rather than product performance per se.

It will remain in established categories, though, that aerosols will continue their recovery; suppliers



Eye makeup (above) uses emollients, solvents, preservatives, and colors, whereas lipstick uses emollients, colors, scents, and flavors

reckon that if the industry could once sell 2.9 billion units in a year, it can again, and more. One cites the case of personal deodorants and antiperspirants. When aerosol products were first introduced, they took over within about four years. "The beneficial properties that won for aerosols in the first place—convenience, hygiene, economy—are being recognized again," he says. Other competing types of packaging, adopted during the past decade, will never be abandoned, because they have been improved over the years, too.

But new aerosols are coming out for both new and established product categories. As one supplier puts it, marketers can "put back money into the business of making money."

Some U.S. marketers of cosmetic products soon will have a positive encouragement to commit themselves to aerosols, especially mousses: the supply of the containers themselves. Most of the present production of the aluminum containers has come from one company, Boxal, an Alusuisse subsidiary, and it has had severe problems keeping up with demand. New technology is being built in the U.S. and Canada, however, and other capacity is being expanded there. The result? A great deal of overcapacity, predicts one aerosol-industry observer.

Except for some of the more basic commodity chemicals used by the



industry, cosmetics and toiletries aren't usually much affected by oversupply problems. But in an industry that uses relatively small quantities, an adequate or snug capacity through the industry can move quickly into the realm of overcapacity, when a number of different firms spot the same opportunity and decide to jump in.

There is the danger, for example, that that is happening now with sunscreen agents—chemicals incorporated into formulations to protect the formulations themselves from

in-container degradation, and to protect consumers from exposure to ultraviolet light.

Historically this tended to be a rather staid business, with suppliers providing material for product protection (used at about 0.1% in the formulation) and material for the classical suntan products (generally 3 to 5%). But that has changed. Dermatologists who used to be regarded as wet blankets and cranks, warning about the dangers of excessive sunbathing, began to be listened to seriously. And in one of the few pieces of regulation welcomed positively by an industry, the Food & Drug Administration decided that manufacturers who incorporated sunscreens into their products could, under appropriate conditions, be allowed to say on product labels, "May help prevent premature aging and wrinkling of skin, and skin cancer, due to sun overexposure." That can't help but be an appealing marketing claim. Different levels of skin-protection formulations came out, from the lowest which encourages sunning on already tanned or dark skins, to sun blocks for extremely fair skin. Concentrations now run from about 3% ultraviolet absorber to as much as 10% of a formulation.

Moreover, cosmetics and toiletries makers began incorporating sunscreen agents into other products—into lip balms, for example, or skin-care lotions and foundations, and even into some hair-care products.

That has broadened the market for sunscreen actives considerably and lured companies in. BASF Wyandotte, for example, bought GAF's ultraviolet inhibitors (much of which goes into sunscreens) business in 1978 and has been marketing its products aggressively. ICI Americas decided to get into the sunscreen actives business, to complement its other product lines for the cosmetics and toiletries industry. Emery Chemicals is not yet in the business, but is at least considering it, for the same reason, to complement its lines.

How long the market will continue to boom, however, remains to be seen. At least one supplier predicts that the market has reached a peak in the growth rate—that the market will continue to grow, but not by the

leaps and bounds of the past five years. "Most major companies are in it," he says, "so unless there are new innovations, new products will only take market from somebody else. Even smaller companies are trying to copy products"—the market, he implies, is filling up.

As it happens, for suppliers to the cosmetics and toiletries industry, most material categories are probably adequately supplied. Business for suppliers is, of course, dependent upon how business is for their major customers—what is happening with Revlon, or Helene Curtis, for example, or Procter & Gamble, and so on, and how frequently the majors decide to launch new products.

"Our business rises and falls with these people," says one supplier. "Because the industry really is fairly mature, growing in proportion to [gross national product], our business comes with new product introductions. When one of the majors launches a new product, the pipeline

fills. There are big surges if your materials are in that product. The new products may give one positive year, then be down the next, though." And in subsequent years, when the product pipelines into the distribution chain have long ago been filled, then business for any newcomer will be only a fraction of that that benefited the first supplier.

It also may depend upon what a supplier is selling. Marketers of specialty raw materials, for example, feel a slightly smug sorrow for those who peddle the commodity items. "You read off the specs and spend the next hour or two haggling on the price," explains one. "It is much easier selling specialties, where you can convince a customer that your material is precisely the one he [or she] needs."

Selling to major customers, in particular, can be fraught with difficulties for suppliers. In the first place, the supplier's major selling point—technical service and backup—is not needed by companies that know much more than suppliers could.

"Basically, the big companies really know your business, and they practically can tell you what you should be charging," laments one supplier. "They want to know how you make the product, what your raw materials are, and so on; they can figure out what your costs are. They know what's happening, for example, to raw material costs for us. People are very astute about this."

For those companies, selling is often responding to bids, and for a half-cent a pound, the company will switch suppliers. "That has taken some of the fun out of selling," says one.

What suppliers find far more satisfying, however, is working with smaller, entrepreneurial companies to develop new cosmetic and toiletry products. To sell to smaller companies, suppliers must get their product approved through a lengthy but rewarding path: by knowing the chemists in the lab and in the development side. The trick is to get a product into the formulation, suppliers agree, as it is being developed. Then once it is in, if the company decides to launch the product, the

company gets that pipeline business. Everyone else is after the fact and must fight against the success of the product to become an approved alternative supplier.

The challenge to the technical department and the formulator, of course, is to come up with new concepts to suggest to marketing, and to meet the demands for concepts marketing has already come up with—whether one is a supplier company or the cosmetics and toiletries maker. (It only seems as though marketing wants only what the lab doesn't have.)

For the smaller cosmetics and toiletries makers, suppliers fill a crucial role. In fact, one says bluntly, "customers depend on suppliers for innovation." There is still an industry predominance of small- to medium-sized suppliers, but the pressure is on these companies to come up with innovations from their chemicals, to have the wherewithal to do the necessary testing—for instance, shelf life, stability, compatibility testing—required to support the new material being suggested for the innovation.

Serving the industry has always been the key, and it is increasingly important. "You have to have an identity," says one supplier, "with sales and technical service to support that." Personal relationships with cosmetics chemists and other executives at the small cosmetics companies are extremely important, as is the ability and willingness to cater to the needs of the small customer. This is perhaps one reason why large companies shy away from the cosmetics and toiletries industry. Most large, commodity chemical companies wouldn't entertain for a minute the thought of making just 1 million lb of some particular chemical for the industry. Many of the suppliers devoted to the business, however, consider as a "major" customer order anything above 1000 lb.

Combine that willingness with good technical service and applications work, and suppliers can build up a surprisingly loyal relationship with their customers. Cosmetics and toiletries companies are still keenly aware of prices, of course, but they will consider switching only among

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Chromatography boosts the business

For cosmetic raw materials, chromatography is steadily increasing its importance as both an analytical and a processing technique.

Du Pont, for example, is actively promoting its high-performance liquid chromatography system for quality control and analysis of fragrance materials. Customers such as Cr  ation et

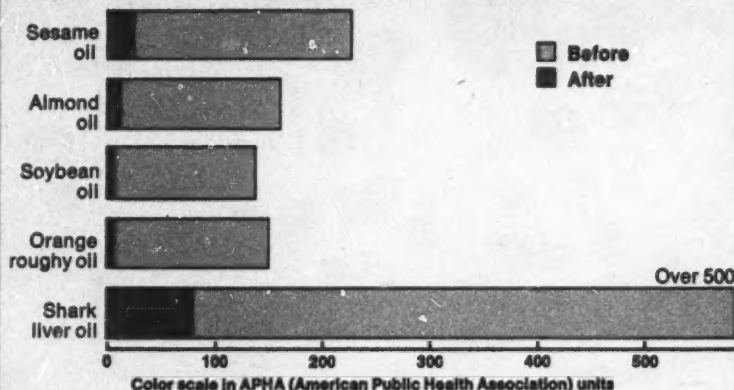
Diffusion Internationale de la Parfumerie, which makes Roger & Gallet toilet soaps and various skin-care and bath products, use the system for analyzing fragrance compounds, in particular. The chromatography is especially gentle on fragrances, which tend to have easily degraded constituents.

On the other hand, chromatography

is a key processing tool for Croda, which has developed a commercial-scale process for purifying and refining natural oil. It has dubbed the process "flash chromatography," and says it is more suited for natural-oil refining than other methods, such as bleaching (which introduces problems of sensitivity and oxidative stability), deodorization either by steam or activated-earth treatment (little improvement in color), washing, and molecular distillation (energy-intensive and unsuited for higher-molecular-weight products such as higher alkyl esters of wool-wax fatty acids).

Most of the details of the process are proprietary; Croda says only that it is a commercially workable scaleup of fine laboratory chromatography, using proprietary adsorbents and "a novel regeneration method." The products tend to be higher priced than those not refined by the process, Croda marketers concede, but they argue that the technique is opening new applications for lanolin derivatives, emollient esters, and natural oils that are otherwise too dark in color or too high in odor characteristics.

Croda uses chromatography to purify natural oils



a certain range of suppliers they have worked with over the years. Similarly, many of the top applications and technical service personnel at supplier companies come from the labs of cosmetics and toiletries houses.

Applications work has been the basis of the industry over the years, and it still is. But there are some shifts occurring. Cosmetic chemists have always had an aura of art about them, and to some extent, that, too, continues—the science must be there in the first place, of course, but in many cases, it comes down to the artistry of putting together a well-functioning, esthetically pleasing product. Notes one supplier, "You only have to go to Eastern Europe and get cosmetics and toiletries there to see the difference esthetics make."

But more and more, researchers within the cosmetics and toiletries industry, and in raw-material supplying companies, are tackling some more fundamental topics, looking not just at the "hows" of products but at the "whys."

They are looking seriously into the

chemistry of skin and hair, for example, finding out what happens if this or that material changes in substantivity, or what happens if a more penetrating product is used. Marketing claims usually are based on very low concentrations of specialty ingredients. What happens if more therapeutic concentrations are incorporated into a formulation? At what point does a product become not just pleasing and esthetic, but actually functional and efficacious? At what point could the activity of vitamins, for instance, be harnessed in an efficacious and healing cosmetic lotion? What effect do proteins have?

Questions like these are taking the industry ever closer to the pharmaceutical industry. It's probably inevitable, for one thing, given the increasingly stringent regulations affecting the cosmetics and toiletries industry from safety to labeling. It is also probably inevitable as cosmetics and toiletries become an ever-more important part of life. There have been extraordinary changes, over the past 30 or 40 years, in how cosmetics

and toiletries are regarded, from rather outr   products, luxuries at best, to necessities. They don't just hide deficiencies, they emphasize positive attributes.

Those attributes can be cosmetic only, but they also can be biological and physiological, suppliers say. Research into how older skin can be regenerated, for example, will be the basis for personal-care products for the increasingly large senior citizen population. Research into how products react differently on different kinds of skins will give even more scientific soundness to products developed for ethnic markets.

The challenge for the cosmetics and toiletries marketers will be not just to put things together to sell, but to understand what is happening and how to control how the product is reacting on, for example, skin or hair. As one supplier notes, "There is a gray area between pharmaceutical over-the-counter products and cosmetics that is growing faster than the other segments. We have to walk the borderline, and that is quite a difficult path." □

MAY 6, 1985

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CHEMICAL & ENGINEERING

NEWS

C&EN's Top

50

Chemical
Products

&

100

Chemical
Producers

Page 11

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News of the Week

■ Trace gases other than carbon dioxide could exert a greater greenhouse effect on Earth's climate, researchers warn. Page 6

■ Presidential commission recommends replacing current chemical weapons with binaries but Congressmen say panelists were biased. Page 7

■ Wolfgang Hilger becomes chairman of Hoechst. Page 7

■ NAS move to renew scientific research exchanges with U.S.S.R. meets opposition. Page 8

■ More than 6000 attended ACS national meeting in Miami Beach. Page 8

■ Photographer snaps palm trees, people at ACS meeting. Page 9

■ Society's new Computer Secretariat will coordinate planning of computer-oriented activities of five ACS divisions. Page 10

■ PCBs are undergoing biodegradation in nature but PAHs may have caused heretofore undetected environmental harm. Page 10

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Business

Philadelphia-based PQ Corp. plans to diversify by acquisitions, other means to increase its share of the chemicals pie. Page 22

International Business

Japanese chemical producers enjoyed a record year in 1984 but how long the boom will last is a matter of conjecture. Page 24

Government

Representatives of 30 states discussed asbestos control problems, exchanged ideas to find unified approach. Page 26

Science

Evidence that lignin in woody tissue has an ordered structure comes from research at Institute of Paper Chemistry. Page 33

Protein portion of infectious agent that causes scrapie is encoded by single gene found in both normal and infected animals. Page 34

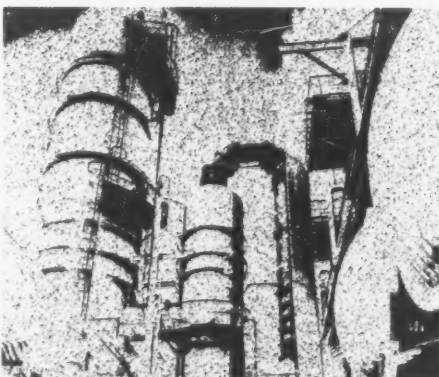
Influential members of House and Senate rush to restore NSF's program on ethics in science to the agency's budget. Page 36

Technology

Electrogenerative reduction can convert pollutant nitric oxides in flue gases into valuable chemicals such as ammonia. Page 39

Priestley Medal Address

Priestley Medalist Henry Taube reminisces about mentor William C. Bray, pioneer of inorganic reaction kinetics studies. Page 40



News Focus

C&EN's Top 50 products, Top 100 producers chalk up a good year for 1984; production volumes increased and operating profits soared. Page 11

C&EN's Top

50

Chemical
Products

&

100

Chemical
Producers

As 1984 began, a full year after the end of the previous economic recession, chemical producers were in full gear. And although the economy tailed off after the first six months, 1984 was, all in all, a good year for the chemical industry.

That is not to say the year was trouble free. Producers had to contend with the effects of the unprecedented strength of the dollar against foreign currencies. Imports increased sharply in many areas, and export markets fled American products for those priced in cheaper currencies. And less expensive imports kept producers from raising prices.

Still, production volumes increased handily. Output of C&EN's Top 50 chemical products jumped 9.2% overall in 1984 from the year before. Organics output rose 9.2%; that of inorganics climbed 9.4% last year.

Because of the intransigence of many product prices, however, the jump in output did not bring with it as big an increase in sales revenues. For C&EN's Top 100 chemical producers, sales totals increased only 7% in 1984 from 1983. At the same time, efficiency measures paid off: Operating profits soared an impressive 41% last year.

C&EN's Top

50

Chemical
Products

Basic chemical production grew strongly in 1984

David Webber
C&EN New York

Production of basic chemicals returned to solid growth in almost all categories

last year. The composite increase in output of C&EN's Top 50 chemicals, which includes both organics and inorganics, totaled some 9.2%, compared with 7.4% in 1983.

All in all, business in the second full year after the last recession ended in late 1982 was good enough to bring most of the stragglers—those products that were unable to reverse their production slump in 1983—into positive growth again. In 1983, for example, the first year of economic recovery, only 36 of the Top 50 chemicals recorded production gains. Last year, by comparison, all but five of the largest-volume prod-

ucts had increases in output. And those were chemicals that for the most part have been declining for the past decade because of long-term problems in their individual industry segments.

Nevertheless, the overall growth in production was not enough to raise totals to the levels reached in 1979, still the peak year historically for chemical output. Five-year compound growth (the base period for which is the big 1979 year) remained negative for both the entire Top 50 group and its two subcategories, organics and inorganics. In fact, the last year in which Top 50 output was higher than in the comparable period five years earlier was 1981. Between 1979 and 1984, production of the Top 50 chemicals declined at an average rate of 1.1%—organics output fell 0.4% per year and inorganics output fell 1.4% per year, on a compounded annual basis.

The overall negative performance of chemical production during the past five years reflects the topsy-

About the Top 50 list of chemical products

Government data, trade association figures, and industry estimates all go into preparing C&EN's annual list of the Top 50 chemical products, ranked by production volume. The federal government is relied upon most heavily, but when government figures are not available, other sources, primarily trade associations, are used. Industry sources and C&EN estimates are used only when other data are lacking.

Government data are not always accurate—they are only as good as the information that individual companies report. But they are an objective measure of production extending back for many years. Therefore, relatively accurate indications of growth can be made on a consistent basis.

At this time of year, C&EN has access only to preliminary reports of production for 1984. When the government and trade associations issue their final reports, the outcome can be changed, sometimes dramatically. As a result, production figures for earlier years that appear in the table on page

13 are different in some cases from those published in last year's Top 50 report. The final reports also can affect the rankings of chemicals. The 1983 rankings of eight of the chemicals listed in the table, for example, are different from those in the similar table published by C&EN a year ago.

The list itself covers production figures for the U.S. and includes chemicals produced for export. Candidates for the list include all basic, intermediate, and chemically homogeneous finished products. These range from chemical building blocks like ethylene and propylene to downstream products like vinyl acetate and ethylene glycol. This year methyl *tert*-butyl ether (MTBE) is included for the first time. Synthetic ethanol, number 50 last year, has been dropped.

The roster also includes basic inorganic chemicals, but does not include what C&EN considers to be minerals, such as salt, gypsum, and sulfur. Lime is included because it is processed

and has many chemical and industrial applications. Refractory (dead-burned) dolomite is excluded in the calculation of lime production.

In the organics list, such petrochemical feedstocks as ethane, butane, and propane are excluded arbitrarily, because they are considered to be products of oil companies and because they have many nonchemical uses.

There are other gray areas besides lime and petrochemical feedstocks. For example, the basic aromatics—benzene, toluene, and xylene—are included. Admittedly, this makes the list less pure chemically.

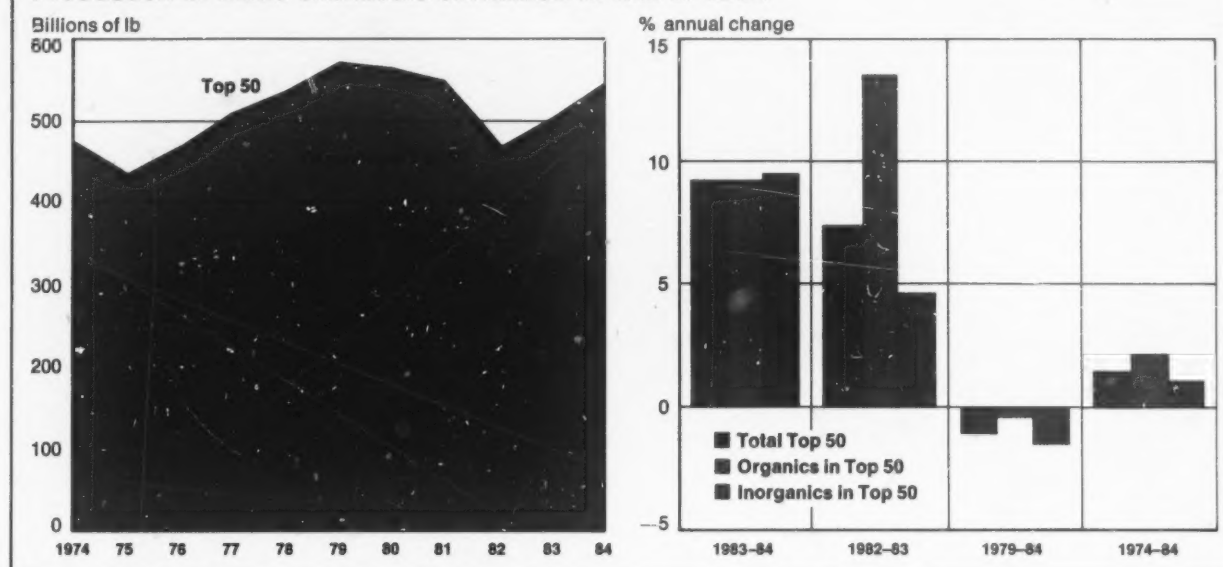
Production figures are published by the government and trade associations in a variety of units—millions of pounds, thousands of tons, billions of cubic feet, millions of gallons, metric tons. To provide an accurate ranking and to make comparison of production volumes easier, C&EN not only gives production in common units but converts production to billions of pounds as well.

Top 50 chemical production increased 9% in 1984

Rank			Billions of lb		Common units ^b		Average annual growth			
1984	1983 ^a		1984	1983	1984	1983	1983-84	1982-83	1979-84	1974-84
1	1	Sulfuric acid	79.37	73.17	39,683 tt	36,583 tt	8.5%	10.1%	-1.7%	1.6%
2	2	Nitrogen	43.41	40.58	599 bcf	560 bcf	7.0	15.9	7.0	9.4
3	6	Ammonia	32.41	28.14	16,204 tt	14,072 tt	15.2	-10.9	-2.8	0.3
4	3	Lime ^c	32.20	29.73	16,100 tt	14,867 tt	8.3	5.6	-5.1	-2.3
5	4	Ethylene	31.18	28.68	31,178 mp	28,677 mp	8.7	17.0	0.8	2.7
6	5	Oxygen	31.04	28.39	375 bcf	343 bcf	9.3	-1.7	-3.8	0.4
7	7	Sodium hydroxide	22.45	20.46	11,224 tt	10,230 tt	9.7	9.0	-2.6	0.0
8	9	Phosphoric acid	22.22	19.53	11,111 tt	9,767 tt	13.8	18.3	1.5	4.4
9	8	Chlorine	21.45	19.92	10,724 tt	9,960 tt	7.7	8.5	-2.6	0.0
10	10	Sodium carbonate ^d	17.02	16.93	8,511 tt	8,467 tt	0.5	8.3	0.6	1.2
11	12	Nitric acid	16.08	13.94	8,041 tt	6,968 tt	15.4	-5.7	-2.0	0.1
12	11	Propylene	15.47	13.96	15,470 mp	13,959 mp	10.8	11.4	1.7	4.0
13	14	Urea ^e	14.30	12.27	7,148 tt	6,137 tt	16.5	-5.1	0.4	6.9
14	13	Ammonium nitrate ^f	14.01	12.48	7,005 tt	6,240 tt	12.3	-12.0	-3.3	0.7
15	15	Ethylene dichloride	13.73	11.51	13,731 mp	11,506 mp	19.3	51.0	3.1	4.1
16	16	Benzene	9.86	9.08	1,339 mg	1,233 mg	8.5	17.2	-4.3	-1.0
17	18	Ethylbenzene	8.61	7.88	8,613 mp	7,876 mp	9.4	18.3	0.4	3.8
18	17	Methanol	8.28	7.98	8,280 mp	7,982 mp	3.7	5.7	2.4	1.9
19	19	Carbon dioxide ^g	7.80	7.76	3,898 tt	3,880 tt	0.5	1.6	5.5	8.0
20	21	Styrene	7.71	6.80	7,706 mp	6,802 mp	13.3	14.5	0.6	2.6
21	20	Vinyl chloride	7.51	6.88	7,513 mp	6,875 mp	9.3	40.2	3.3	2.9
22	26	Xylene	6.12	5.23	850 mg	726 mg	17.1	10.3	-2.6	0.6
23	23	Terephthalic acid ^h	6.05	5.63	6,047 mp	5,626 mp	7.5	16.2	0.4	3.6
24	24	Ethylene oxide	5.96	5.53	5,957 mp	5,534 mp	7.6	11.0	0.7	3.4
25	27	Hydrochloric acid	5.72	4.84	2,862 tt	2,420 tt	18.3	-1.2	-1.5	1.5
26	25	Formaldehyde ⁱ	5.71	5.47	5,712 mp	5,465 mp	4.5	13.5	-0.9	-0.1
27	22	Toluene ^j	5.27	5.66	726 mg	780 mg	-6.9	9.2	-6.4	-2.4
28	28	Ethylene glycol	4.84	4.43	4,842 mp	4,425 mp	9.4	2.7	0.5	3.8
29	29	p-Xylene	4.27	4.11	4,268 mp	4,114 mp	3.7	28.3	-1.7	4.7
30	30	Ammonium sulfate	4.13	3.91	2,063 tt	1,956 tt	5.5	10.6	-2.7	-0.3
31	32	Potash ^k	3.53	3.15	1,600 tmt	1,429 tmt	12.0	-19.9	-6.4	-4.6
32	31	Cumene	3.36	3.35	3,360 mp	3,345 mp	0.4	21.9	-3.0	1.5
33	35	Carbon black	2.89	2.50	2,893 mp	2,496 mp	15.9	8.4	-2.8	-1.5
34	34	Phenol ^l	2.85	2.64	2,845 mp	2,637 mp	7.9	30.4	-0.9	2.0
35	33	Acetic acid	2.64	2.81	2,642 mp	2,807 mp	-5.9	2.1	-4.1	0.2
36	36	Butadiene ^m	2.53	2.35	2,531 mp	2,353 mp	7.6	22.9	-6.7	-3.7
37	38	Acrylonitrile	2.20	2.15	2,201 mp	2,146 mp	2.6	5.5	1.8	4.5
38	37	Aluminum sulfate	2.16	2.21	1,079 tt	1,103 tt	-2.2	-4.3	-3.9	-1.5
39	44	Cyclohexane	2.13	1.66	2,130 mp	1,656 mp	28.6	29.9	-2.6	-1.0
40	42	Calcium chloride ⁿ	2.10	1.71	1,049 tt	857 tt	22.4	0.5	1.3	-0.5
41	39	Vinyl acetate	2.02	1.96	2,023 mp	1,963 mp	3.1	4.6	0.4	3.7
42	41	Propylene oxide	1.90	1.80	1,900 mp	1,800 mp	5.6	7.1	-3.3	0.8
43	40	Acetone	1.89	1.86	1,887 mp	1,859 mp	1.5	9.7	-6.6	-0.5
44	43	Sodium sulfate ^o	1.74	1.71	872 tt	854 tt	2.1	-1.2	-4.9	-4.3
45	45	Titanium dioxide	1.60	1.51	799 tt	757 tt	5.5	15.2	1.5	0.2
46	46	Sodium silicate	1.50	1.46	750 tt	728 tt	3.0	9.6	-1.6	-0.3
47	—	Methyl tert-butyl ether ^p	1.47	0.84	1,469 mp	839 mp	75.1	1.8	nm	nm
48	48	Adipic acid	1.39	1.28	1,390 mp	1,280 mp	8.6	10.6	-4.4	-0.6
49	47	Sodium tripolyphosphate	1.33	1.34	667 tt	669 tt	-0.3	2.8	-2.5	-3.0
50	49	Isopropyl alcohol	1.15	1.21	1,147 mp	1,209 mp	-5.1	-12.4	-9.6	-5.1
TOTAL ORGANICS			180.39	164.97			9.2%	13.5%	-0.4%	2.2%
TOTAL INORGANICS			366.15	335.38			9.4%	4.7%	-1.4%	1.1%
GRAND TOTAL			546.54	500.35			9.2%	7.4%	-1.1%	1.4%

a Revised. b tt = thousands of tons, bcf = billions of cubic feet, mp = millions of pounds, mg = millions of gallons, tmt = thousands of metric tons. c Except refractory dolomite. d Synthetic and natural. e 100% basis. f Original solution. g Liquid and solid only. h Includes both acid and ester without double counting. i 37% by weight. j All grades. k K₂O basis. l Synthetic only. m Rubber grade. n Solid and liquid. o High and low purity. p First year in which qualified for inclusion in Top 50; ethanol has been excluded. nm = not meaningful. Sources: Bureau of the Census, Bureau of Mines, International Trade Commission, C&EN estimates

Production of basic chemicals continued to rise in 1984



turvy nature of the nation's economy during the early 1980s. The general maturity of the basic chemicals industry is reflected even more in composite growth figures for the past 10 years. Since 1974, the entire group's production has increased at a compound annual rate of just 1.4%. Inorganics output grew just 1.1% per year and organics output 2.2% per year over that span. And the decline is widespread: 17 of the Top 50 chemicals recorded lower production in 1984 than in 1974. Output of another 10 products has grown at an annual compound rate of less than 1% over the past decade.

Still, there were some impressive gains made in 1984 compared with 1983. Of the Top 50 group, 15 products recorded production increases of more than 10%. The greatest growth was registered by one of the smallest of the group: methyl *tert*-butyl ether (MTBE), output of which was 75% higher than in 1983. MTBE, which five years ago was not produced in enough volume to merit even an individual line entry in the International Trade Commission's annual compendium of synthetic organic chemicals production, was elevated into the Top 50 group for the first time in 1984, thanks to its increasing use in gasoline and the bringing on stream of a number of new MTBE production facilities.

The inclusion of MTBE displaced synthetic ethanol, which finally managed to shrink itself off the list. Ethanol production increased in each of the past two years—up 2.9% in the 1983-84 period and up 5.3% in the 1982-83 period. However, over the past decade, the product has been one of the fastest decreasing chemicals, at an annual compound decline of 3.7%.

After MTBE, the next biggest production gains in 1984 compared to 1983 were recorded by (in order) cyclohexane, up 29%; calcium chloride, up 22%; ethylene dichloride, up 19%; and hydrochloric acid, up

18%. The five worst performers in terms of output were: toluene, battered by the slumping gasoline business and competition from MTBE, down 6.9%; acetic acid, down 5.9%; isopropyl alcohol, down 5.1%; aluminum sulfate, down 2.2%; and sodium tripolyphosphate, down less than 1%.

The picture for production changes over the past 10 years is somewhat different. Over that span, the best performer has been nitrogen, output of which grew between 1974 and 1984 at an average annual rate of 9.4%. Next best was another industrial gas, carbon dioxide; output of liquid and solid forms of carbon dioxide increased at a compound rate of 8%. Following were urea, up 6.9% per year; *p*-xylene, up 4.7% per year; and acrylonitrile, up 4.5% per year over the past decade.

Over the past 10 years, the greatest declines in production have been registered by isopropyl alcohol, output of which has plunged at an average annual rate of 5.1%; potash, down 4.6% per year; sodium sulfate, down 4.3% per year; butadiene, despite two annual production increases in a row for synthetic rubber, down 3.7% per year; and sodium tripolyphosphate, down 3% per year. There are no real surprises in the group: All were in the five worst category in 1983 as well, with the exception of sodium tripolyphosphate, which would have been had ethanol been excluded from that dubious honor.

There were many changes in ranking between 1983 and 1984, but most of them involved no more than the transposition of two products on sequential echelons. The most notable differences were ammonia, which jumped from sixth place in 1983 to third last year; xylene, which climbed from 26 to 22; toluene, which dropped from 22 to 27; cyclohexane, which rose from 44 to 39; and acetone, which fell from 40 in 1983 to 43 last year. □

C&EN's Top

100

Chemical Producers

Sales, profits rose for largest chemical producers

William J. Storck
C&EN New York

Chemical producers generally did well last year. Both sales and operating prof-

its were up despite lower prices, foreign competition in both domestic and export markets because of the high value of the dollar, and a rather lackluster capacity use picture. Granted, chemical executives had more to complain about as 1984 ground on, but overall, results were fairly impressive, especially when compared with those for prior years.

A number of end-use markets turned up for produc-

ers, chiefly autos and housing. However, the one that made the most difference for many companies was agriculture. In 1984, the government's payment-in-kind crop set-aside program was all but ended, providing rapidly increasing markets for all agricultural chemicals—pesticides and fertilizers—as farmers were once again increasing planted acreage.

Thus, with market opportunities increasing as opposed to the past few years, the number of producers with declining sales from chemicals were few. Of the companies on C&EN's list of the Top 100 chemical producers (in terms of sales from chemical operations), only 14 registered a decline in chemical sales in 1984 from the year before. Sales from chemicals for the companies grew almost 8% in 1984 to \$127 billion.

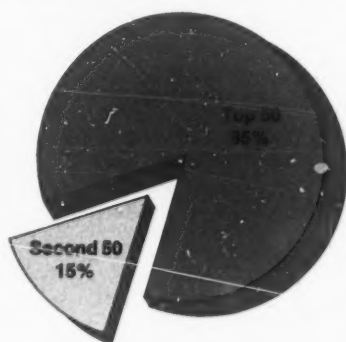
In the combined listing for 1983, 34 producers had declines in chemical sales from the year before.

Operating profits from chemicals also increased last year with the growth dwarfing that for sales. Chemical operating profits (generally sales minus administrative costs and costs of goods) for the companies that reported this figure increased an average of 41% from 1983 to \$11.0 billion.

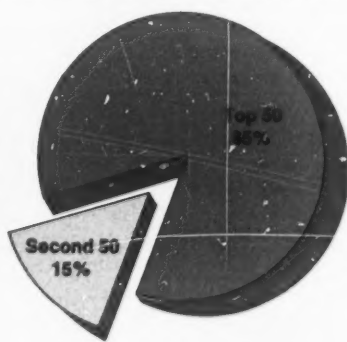
Once again, Du Pont is the U.S.'s largest chemical producer, with about \$12.0 billion in chemical sales, up 3.4% from the year before. In fact, Du Pont typifies the stability of the top 10 producers. All of the first 10 for 1984 comprised the top 10 for 1983. There is no change in ranking until six on the list. For 1984, Shell, which had been ranked seven in 1983, traded places with Celanese, which had been six that year. The other change in the first 10 is Atlantic Richfield, which moved up two notches to eight, and Standard Oil (Ind.), now Amoco Corp., fell from eighth place, replacing Arco as 10 on the list.

There are a number of firsts associated with this year's listing. Although C&EN has been ranking the Top 100 for several years, this is the first time that the listing has been put together in one issue.

Larger companies dominate chemical sales, earnings ...

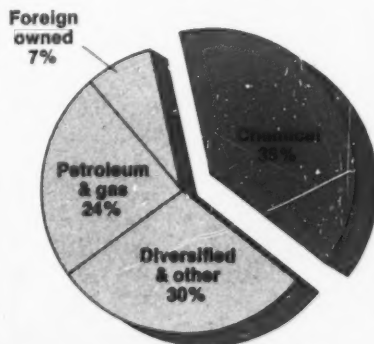


1984 sales = \$127 billion

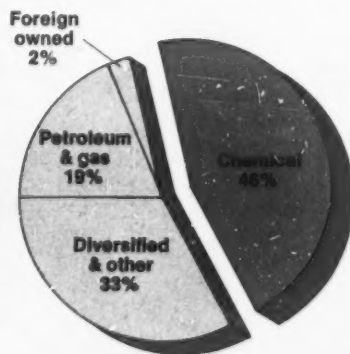


1984 operating profits = \$11 billion

... and among types of firms, chemicals perform best



1984 sales = \$127 billion



1984 operating profits = \$11 billion

Operating results improved for most chemical producers in 1984

Rank 1984	Rank 1983	Company	Chemical sales 1984 (\$ millions)	Change from 1983	Chemical sales as % of total sales	Industry classification	Chemical operating profits 1984 ^a (\$ millions)	Change from 1983	Chemical operating profits as % of total operating profits	Operating profit margin ^b	Identifi- fiable chemical assets 1984 (\$ millions)	Chemical assets as % of total assets	Operating return on chemical assets ^c
1	1	Du Pont	\$12,005	3.4%	32.3%	Diversified	\$1107	-3.2%	25.4%	9.2%	\$7538	34.3%	14.7%
2	2	Dow Chemical	9,591	8.1	77.7	Basic chemicals	741	29.3	87.4	7.7	7645	66.9	9.7
3	3	Exxon	6,870	7.5	6.7	Petroleum	677	80.1	6.5	9.9	5246	8.3	12.9
4	4	Monsanto	5,951 ^d	7.6	82.6	Basic chemicals	669	35.7	98.8	11.2	5054	79.3	13.2
5	5	Union Carbide	4,158	6.3	41.1	Basic chemicals	480	74.5	49.3	11.5	4683	46.4	10.2
6	7	Shell Oil	3,383	4.8	13.6	Petroleum	273	110.0	8.5	8.1	3624	15.3	7.5
7	6	Celanese	3,328	2.1	98.0	Basic chemicals	272	27.1	100.0	8.2	3104	100.0	8.8
8	10	Atlantic Richfield	3,144	23.3	10.3	Petroleum	148	131.3	3.9	4.7	2616	11.8	5.7
9	9	W. R. Grace	2,848	3.2	41.0	Specialty chemicals	336	3.7	57.7	11.8	1779	36.3	18.9
10	8	Amoco Corp.	2,834	-2.5	10.0	Petroleum	349	101.7	8.2	12.3	2249	9.6	15.5
11	12	Mobil	2,607	11.8	3.9	Petroleum	56	def	1.1	2.1	2258	5.7	2.5
12	13	Eastman Kodak	2,464	7.8	21.1	Photo equipment	281	31.3	18.2	11.4	2054	19.1	13.7
13	11	Allied	2,433	4.1	21.8	Diversified	231	3.1	17.2	9.5	1345	16.4	17.2
14	14	Phillips Petroleum	2,351	4.3	14.5	Petroleum	221	166.3	8.9	9.4	1498	8.8	14.8
15	—	General Electric	2,117	7.8	6.8	Electrical products	470	42.9	12.1	22.2	2362	9.6	19.9
16	16	Rohm & Haas	1,962	8.5	88.5	Basic chemicals	333	11.7	103.4	17.0	1293	95.2	25.8
17	18	American Cyanamid	1,838	10.4	44.6	Basic chemicals	125	27.0	38.4	7.1	1273	53.7	10.6
18	15	Hercules	1,823	-9.2	78.1	Basic chemicals	129	6.6	61.4	7.1	1335	78.9	9.7
19	20	Air Products ^a	1,601	13.7	81.3	Basic chemicals	292	49.2	107.1	18.2	1731	74.3	16.9
20	25	Ciba-Geigy	1,500	21.0	54.6	Specialty chemicals	na	na	na	na	na	na	na
21	29	Texaco	1,538	35.3	2.4	Petroleum	39	def	1.0	2.5	1008	3.0	3.9
22	21	Stauffer Chemical ^a	1,504	12.2	89.1	Basic chemicals	129	def	100.0	8.6	1601	100.0	8.1
23	27	Ashland Oil	1,501	24.3	13.5	Petroleum	55	5400.0	21.6	3.7	503	14.6	10.9
24	22	Mobay	1,500	15.4	86.7	Basic chemicals	135 ^f	103.9	100.0	9.0	na	na	na
25	26	American Hoechst	1,468 ^a	20.1	69.4	Basic chemicals	na	na	na	na	na	na	na
26	24	Borden	1,448	11.8	28.4	Dairy products	170	23.5	41.2	11.7	1340	48.6	12.7
27	30	B. F. Goodrich	1,424	25.7	34.6	Rubber products	114	157.8	68.6	8.0	1366	56.5	8.4
28	32	U. S. Steel	1,365	21.0	5.9	Steel	57	def	3.6	4.2	613	3.5	9.3
28	19	Ethyl	1,365 ^a	-7.7	88.2	Basic chemicals	190	21.6	85.2	13.9	790	80.8	24.0
30	31	Unocal Corp.	1,249	10.3	9.8	Petroleum	87 ^f	18.1	12.5	7.0	747	7.3	11.7
31	23	FMC	1,236	-4.7	38.8	Machinery	187	10.6	47.5	15.1	985	53.4	19.0
32	35	BASF Wyandotte	1,185	14.6	87.3	Basic chemicals	34	72.2	100.0	2.9	na	na	na
33	33	Olin	1,174	5.6	53.8	Basic chemicals	61	-10.6	35.1	5.2	1021	62.9	5.9
34	34	Standard Oil of Calif.	1,100	3.9	3.8	Petroleum	11 ^f	def	0.7	1.0	847	4.2	1.3
35	42	National Distillers	1,081	37.6	35.0	Alcoholic beverages	102	49.6	50.0	9.4	763	40.4	13.3
36	38	PPG Industries	993	12.6	20.8	Glass products	122	63.1	20.9	12.3	1150	35.8	10.6
37	28	Occidental Petroleum	985 ^a	-13.4	7.0	Petroleum	69	def	4.2	7.0	991	8.1	6.9
38	36	International Minerals ^b	977	-1.9	63.5	Agrichemicals	146	-6.6	63.0	14.9	1323	67.3	11.0
39	40	Borg-Warner	944	14.3	21.1	Auto equipment	121	10.1	31.3	12.8	376	20.3	32.3
40	39	CF Industries	908 ^d	5.3	94.9	Agrichemicals	54	58.4	100.0	6.0	1014	100.0	5.4
41	57	Koppers	885	8.2	45.0	Diversified	18	-15.4	22.9	2.0	468	43.3	3.8
42	43	Dow Corning	855	12.0	89.3	Specialty chemicals	91 ^f	33.0	100.0	10.6	na	na	na
43	41	Lubrizol	832	5.3	94.9	Specialty chemicals	102	3.7	100.0	12.3	702	100.0	14.6
44	45	Williams Cos.	831	12.3	21.8	Agrichemicals	68	9628.6	17.7	8.2	932	20.6	7.3
45	37	Diamond Shamrock	820	-12.9	21.0	Petroleum	116	869.2	22.9	14.2	764	14.2	15.2
46	44	Reichhold Chemicals	801	7.2	93.3	Basic chemicals	44	26.1	100.0	5.4	361	100.0	12.1
47	58	Farmland Industries	783	44.5	10.3	Agricultural supplies	32	def	27.6	4.1	447	37.0	7.1
48	46	Eli Lilly	757	4.1	23.4	Drugs	108	10.0	13.2	14.2	773	21.2	13.9
49	48	Badische	709	5.6	94.7	Basic chemicals	33	11.2	100.0	4.6	518	100.0	6.3
50	56	Standard Oil (Ohio)	707	24.9	4.6	Petroleum	44	def	1.5	6.2	664	3.8	6.6

Rank 1984 1983	Company	Chemical sales 1984 (\$ millions)	Change from 1983	Chemical sales as % of total sales	Industry classification	Chemical operating profits 1984 ^a (\$ millions)	Change from 1983	Chemical operating profits as % of total operating profits	Operating profit margin ^b	Identifi- able chemical assets 1984 (\$ millions)	Chemical assets as % of total assets	Operating return on chemical assets ^c
51 52	Uniroyal	272	13.3	27.9	Rubber products	110	59.0	47.5	18.4	443	39.0	24.9
52 49	Nalco Chemical	664	0.7	99.3	Specialty chemicals	115	-2.0	100.0	17.3	479	100.0	24.0
53 51	Pennwalt	656	8.3	57.8	Basic chemicals	52	19.8	66.4	7.9	506	69.9	10.2
54 65	Morton Thiokol ^h	654	45.9	22.4	Diversified	81	72.0	35.2	12.4	497	43.0	16.3
55 50	Merck	642	6.0	17.0	Drugs	78	49.3	9.7	12.2	596	16.8	13.1
56 55	Witco Chemical	823	9.0	38.2	Specialty chemicals	65	20.7	41.7	10.5	271	35.8	24.1
57 59	National Starch	561	10.5	60.3	Specialty chemicals	na	na	na	na	na	na	na
58 82	Engelhard	560	-1.1	22.6	Specialty metals	66	-7.9	58.7	11.8	442	51.2	14.9
59 63	Cabot ^g	542	17.8	26.3	Specialty metals	67	53.9	31.6	12.4	281	16.1	24.0
60 67	Kerr-McGee	520	18.5	12.4	Petroleum	-25	def	def	def	580	16.0	def
61 66	Freeport-McMoRan	493	11.9	52.3	Agrichemicals	110	47.8	87.3	22.2	220	11.5	49.8
62 62	International Flavors	477	3.4	96.7	Specialty chemicals	116	4.6	100.0	24.3	368	100.0	31.5
63 60	NL Industries	473	0.6	34.5	Petroleum services	95	50.8	91.1	20.1	283	21.6	33.5
64 68	Polysar	464	6.5	93.9	Basic chemicals	na	na	na	na	na	na	na
65 69	H. B. Fuller ⁱ	447	4.9	95.3	Specialty chemicals	32	-3.4	100.0	7.2	226	100.0	14.2
66 47	Georgia-Pacific	446	-34.7	9.6	Wood products	-134	def	def	def	158	3.3	def
67 70	Henkel	430	7.5	93.0	Specialty chemicals	na	na	na	na	na	na	na
68 72	Liquid Air	426	9.3	77.7	Basic chemicals	52	6.6	96.3	12.2	na	na	na
69 61	Sun Co.	422	-9.0	3.0	Petroleum	na	na	na	na	na	na	na
70 73	InterNorth	396	5.7	5.0	Natural gas	47	76.8	8.1	11.9	636	10.8	7.4
71 71	Pfizer	377	-4.4	10.2	Drugs	5	-10.0	0.5	1.2	382	9.4	1.2
72 81	Rhône-Poulenc	370	27.6	78.4	Specialty chemicals	na	na	na	na	na	na	na
72 90	Terra Chemicals	370	30.7	76.5	Agrichemicals	na	na	na	na	na	na	na
74 89	SCM ^h	361 ^d	43.9	12.5	Paint	37	144.3	32.4	10.2	317	27.3	11.6
75 74	GAF	357	10.5	44.2	Specialty chemicals	79	22.3	57.2	22.1	204	45.1	38.8
76 78	Soltex	350	16.7	85.7	Basic chemicals	na	na	na	na	na	na	na
77 84	Mississippi Chemical ^h	349	32.8	75.3	Farm cooperative	4	-2.9	100.0	1.2	352	100.0	1.2
78 77	Tyler	346	13.6	32.8	Diversified chemical	7	-67.3	22.9	2.1	160	33.2	4.5
79 79	Big Three Industries	339	15.6	37.8	Petroleum services	76	6.8	62.0	22.3	576	49.9	13.1
80 80	Upjohn	325	11.7	13.4	Drugs	-9	def	def	def	191	8.5	def
81 88	Chemed	318	26.2	72.7	Specialty chemicals	42	20.2	90.4	13.1	151	85.5	27.7
81 75	American Petrofina	318	2.5	14.6	Petroleum	20	293.1	38.1	6.4	308	18.8	6.6
83 86	Vulcan Materials	302	18.1	26.0	Nonmetallic minerals	47	224.0	35.8	15.6	na	na	na
84 83	Petrolite ⁱ	284	6.6	90.7	Specialty chemicals	41	23.5	105.2	14.2	160	72.4	25.2
85 93	Great Lakes Chemicals	278	23.1	81.2	Specialty chemicals	57	44.2	100.0	20.3	284	100.0	19.9
86 91	Aluminum Co. of America	273	13.5	4.2	Nonferrous metals	na	na	na	na	na	na	na
86 92	Ferro	273 ^d	13.4	36.2	Specialty materials	16	-1.8	31.7	5.8	140	42.5	11.2
88 87	Baker Industries	264	4.5	95.7	Agrichemicals	16	1521.4	100.0	6.1	341	100.0	4.8
89 85	Emhart	261	1.0	14.4	Machinery	23	-4.6	10.9	8.7	111	11.5	20.5
90 53	Kaiser Aluminum	249	-57.3	18.2	Nonferrous metals	39	58.6	67.0	15.6	281	8.0	13.8
91 94	Loctite	242	12.0	89.3	Specialty chemicals	43	48.0	100.0	17.8	227	100.0	18.9
92 96	Stepan Chemical	235	13.4	88.2	Specialty chemicals	6	-45.0	100.0	2.6	134	100.0	4.6
93 —	Northwest Industries	216	2.5	14.7	Diversified	27	13.2	11.9	12.3	163	10.7	16.2
94 97	Essex Chemical	176	4.2	95.9	Basic chemicals	27	59.3	100.0	15.4	111	100.0	24.4
95 98	Agway	166	2.1	4.0	Farm cooperative	na	na	na	na	na	na	na
96 —	First Mississippi	165	52.5	40.1	Agrichemical	28	37.3	64.8	17.2	82	25.9	34.6
97 100	Sterling Drug	145	6.1	7.5	Diversified	9	21.6	3.4	6.0	118	8.1	7.4
98 —	Crompton & Knowles	115	-1.6	60.9	Specialty chemicals	14	5.9	64.3	11.8	58	56.3	20.1
99 —	Avon Products	114	10.4	3.3	Diversified	17	37.7	4.5	14.8	156	6.4	10.7
100 99	UGI Corp.	113	-24.0	22.2	Natural gas	1	def	1.2	0.7	125	22.1	0.6

^a Operating profit defined as sales less administrative expense and cost of sales. ^b Operating profit from chemicals as a percentage of total operating profits. ^c Operating profit as a percentage of identifiable chemical assets. ^d Chemical sales include significant amounts of nonchemical products. ^e Fiscal year ended Sept. 30. ^f Chemical net profits. ^g Does not include all chemical profits. ^h Fiscal year ends June 30. ⁱ Fiscal year ends Nov. 30. ^j Fiscal year ends Oct. 31. na = not available. def = deficit.

C&EN's Top 100 chemical producers are ranked five ways

\$ Millions	Chemical sales			Chemical operating profits			Chemical operating profit margin			Identifiable chemical assets			Return on chemical assets		
	Rank			Rank			Rank			Rank			Rank		
	1984	1984	1983	1984	1984	1983	1984	1984	1983	1984	1984	1983	1984	1984	1983
Agway	\$ 166	95	98	na	—	—	na	—	—	na	—	—	na	—	—
Air Products	1,804	19	20	\$ 292	10	11	18.2%	8	11	\$1731	14	13	16.9%	24	30
Allied	2,493	13	11	231	14	8	9.5	45	30	1345	18	18	17.2	23	17
Aluminum Co. of America	273	86	91	na	—	—	na	—	—	na	—	—	na	—	—
American Cyanamid	1,898	17	18	135	21	22	7.1	58	50	1273	23	19	10.6	49	44
American Hoechst	1,468	25	26	na	—	—	na	—	—	na	—	—	na	—	—
American Petrofina	318	81	76	20	71	69	6.4	61	71	308	60	77	6.6	65	64
Amoco Corp.	2,834	10	8	349	7	12	12.3	28	52	2249	11	9	15.5	27	47
Ashland Oil	1,501	23	27	55	49	72	3.7	73	76	503	46	57	10.9	47	71
Atlantic Richfield	3,144	6	10	148	19	35	4.7	69	68	2616	8	8	5.7	69	66
Avon	114	99	—	17	73	—	14.2	19	—	156	75	—	10.7	48	—
Badische	709	49	49	33	64	53	4.6	70	62	518	44	47	6.3	67	56
BASF Wyandotte	1,185	32	35	34	63	61	2.9	74	70	na	—	38	na	—	65
Baker Industries	264	88	88	16	74	72	6.1	63	75	341	58	65	4.8	71	70
Big Three Industries	339	79	80	76	39	29	22.3	2	1	576	43	45	13.1	39	28
Borden	1,448	26	24	170	18	16	11.7	38	25	1340	19	17	12.7	42	33
Borg-Warner	944	39	40	121	25	21	12.8	25	16	376	54	62	32.3	5	3
Cabot	542	59	64	67	42	42	12.4	26	31	281	63	69	24.0	13	18
Celanese	3,328	7	6	272	13	9	8.2	51	47	3104	7	7	8.8	56	46
CF Industries	908	40	39	54	50	49	6.0	64	64	1014	26	29	5.4	70	63
Chemed	318	81	89	42	58	46	13.1	24	12	151	76	82	27.7	7	5
Ciba-Gelgy	1,560	20	25	na	—	—	na	—	—	na	—	—	na	—	—
Crompton & Knowles	115	98	—	14	76	—	11.8	35	—	68	84	—	20.1	17	—
Diamond Shamrock	820	45	37	116	26	66	14.2	20	73	764	34	25	15.2	28	69
Dow Chemical	9,591	2	2	741	2	2	7.7	56	48	7645	1	1	5.7	53	49
Dow Corning	855	42	44	na	—	—	—	—	36	na	—	—	na	—	—
Du Pont	12,005	1	1	1107	1	1	9.2	48	29	7538	2	2	14.7	31	20
Eastman Kodak	2,484	12	13	281	11	9	11.4	40	33	2054	12	11	13.7	36	34
Eli Lilly	757	48	47	108	32	24	14.2	20	13	773	33	36	13.9	34	29
Emhart	261	89	86	23	70	57	6.7	49	35	111	81	85	20.5	16	10
Engelhard	560	58	57	66	43	28	11.8	35	18	442	52	50	14.9	29	20
Essex Chemical	176	94	97	27	68	62	15.4	16	28	111	81	84	24.4	11	23
Ethyl	1,365	26	19	190	16	14	13.9	23	25	790	32	33	24.0	13	15
Exxon	6,870	3	3	677	3	4	9.9	44	55	5246	3	3	12.9	41	47
Farmland Industries	783	47	59	32	65	83	4.1	72	—	447	50	55	7.1	63	—
Ferro	273	66	92	16	74	62	5.8	66	42	140	77	87	11.2	45	8
First Mississippi	165	96	—	28	67	—	17.2	11	—	82	83	—	34.6	3	—
FMC	1,236	31	23	187	17	13	15.1	17	17	985	29	25	19.0	20	19
Freeport-McMoRan	493	61	67	110	30	27	22.2	3	6	220	68	70	49.8	1	2
H. B. Fuller	447	64	70	32	65	51	7.2	57	41	226	67	72	14.2	33	22
GAF	357	75	75	79	37	33	22.1	5	3	204	69	74	38.8	2	1
General Electric	2,117	15	—	470	6	—	22.2	3	—	2362	9	—	19.9	18	—
Georgia-Pacific	446	66	48	134	85	35	def	—	33	158	74	28	def	—	54
B. F. Goodrich	1,424	27	30	114	29	42	8.0	54	66	1366	17	20	8.4	57	61
V. R. Grace	2,848	9	9	336	8	5	11.8	35	22	1779	13	14	16.9	21	12
Great Lakes Chemical	278	84	93	57	46	45	20.3	6	5	284	61	71	19.9	18	15
Henkel	430	67	71	na	—	—	na	—	—	na	—	—	na	—	—
Hercules	1,823	18	15	129	22	18	7.1	58	52	1335	20	21	9.7	63	36
International Flavors	477	62	63	116	26	20	24.3	1	2	368	55	56	31.5	6	6
International Minerals	977	38	36	146	20	14	14.9	18	9	1323	21	16	11.0	46	31

\$ Millions	Chemical sales			Chemical operating profits			Chemical operating profit margin			Identifiable chemical assets			Return on chemical assets		
	Rank			Rank			Rank			Rank			Rank		
	1984	1984	1983	1984	1984	1983	1984	1984	1983	1984	1984	1983	1984	1984	1983
InterNorth	396	70	74	47	53	56	11.9	34	44	636	39	58	7.4	60	51
Kaiser Aluminum	249	90	54	39	60	57	15.6	14	63	281	63	49	13.8	35	59
Kerr-McGee	520	60	68	25	84	81	def	—	—	560	42	43	def	—	—
Koppers	885	41	41	18	72	60	2.0	79	68	468	49	51	3.8	75	60
Liquid Air	426	68	73	52	51	40	12.2	32	18	na	—	52	na	—	32
Loctite	242	91	94	43	57	54	17.3	9	13	227	66	73	18.9	21	27
Lubrizol	832	43	42	102	33	23	12.3	28	18	702	37	40	14.6	32	24
Merck	642	55	51	78	38	39	12.2	32	38	596	41	44	13.1	39	41
Mississippi Chemical	349	77	85	4	81	71	1.2	80	72	352	57	64	1.2	77	67
Mobay	1,500	24	22	na	—	—	—	—	59	na	—	22	na	—	—
Mobil	2,607	11	12	56	48	79	2.1	77	—	2,258	10	10	2.5	78	—
Monsanto	5,951	4	4	669	4	3	11.2	41	37	5,054	4	5	13.2	38	34
Morton Thiokol	654	54	65	81	36	41	12.4	26	27	497	47	46	16.3	25	40
Naico Chemical	664	52	50	115	28	19	17.3	10	4	479	48	48	24.0	13	7
National Distillers	1,031	35	43	102	33	30	9.4	46	38	763	35	40	13.3	37	37
National Starch	561	57	60	na	—	—	na	—	—	na	—	—	na	—	—
NL Industries	473	63	61	95	35	37	20.1	7	16	283	62	66	33.5	4	11
Northwest Industries	216	93	—	27	68	—	12.3	28	—	163	71	—	16.2	26	—
Occidental Petroleum	985	37	28	69	40	77	7.0	60	—	991	28	32	6.9	64	—
Olin	1,174	33	33	61	45	30	5.2	68	51	1,021	25	31	5.9	68	50
Pennwalt	656	53	52	52	51	44	7.9	55	44	506	45	54	10.2	51	38
Petrolite	284	84	84	41	59	51	14.2	20	21	160	72	80	25.2	9	9
Pfizer	377	71	72	5	80	69	1.2	80	73	382	53	59	1.2	78	67
Phillips Petroleum	2,351	14	14	221	15	25	9.4	48	67	1,498	16	15	14.8	30	55
Polysar	484	64	69	na	—	—	na	—	—	na	—	—	na	—	—
PPG Industries	993	36	38	122	24	26	12.3	28	40	1,150	24	23	10.6	49	52
Reichhold Chemicals	801	46	45	44	55	46	5.4	67	61	361	56	61	12.1	43	36
Rhône-Poulenc	370	72	82	na	—	—	0.0	—	—	na	—	—	na	—	—
Rohm & Haas	1,962	16	16	333	9	6	17.0	12	7	1,293	22	27	25.8	8	4
SCM	361	74	90	37	62	64	10.2	43	52	317	59	68	11.6	44	56
Shell Oil	3,383	6	7	273	12	17	8.1	53	64	3,624	6	6	7.5	59	82
Soltex	350	76	79	na	—	—	na	—	—	na	—	—	na	—	—
Standard Oil (Ohio)	707	50	57	44	55	76	8.2	62	—	664	38	42	8.6	65	—
Standard Oil of Calif.	1,100	34	34	na	—	—	—	—	—	847	31	37	na	—	—
Stauffer Chemical	1,504	22	21	129	22	78	8.6	50	—	1,601	15	12	8.1	58	—
Stepan Chemical	235	92	96	6	79	67	2.6	75	57	134	78	81	4.6	72	45
Sterling Drug	145	97	100	9	77	68	6.0	94	58	118	80	86	7.4	60	53
Sun Co.	422	69	82	na	—	—	na	—	—	na	—	—	na	—	—
Terra Chemicals	370	72	83	na	—	—	na	—	—	na	—	78	na	—	—
Texaco	1,536	21	26	39	60	84	2.5	76	—	1,008	27	34	3.9	74	—
Tyler	346	78	78	7	78	59	2.1	77	42	160	73	79	4.5	73	36
UGI Corp.	113	100	99	1	82	75	0.7	82	—	125	79	83	0.6	79	—
Union Carbide	4,158	5	5	480	5	7	11.5	39	46	4,683	5	4	10.2	51	58
Unroyal	672	51	53	110	30	33	16.4	13	23	443	51	52	24.9	10	25
Unocal Corp.	1,249	30	30	na	—	—	—	—	48	747	36	39	na	—	—
Upjohn	325	80	81	9	83	80	def	—	—	191	70	76	def	—	—
U.S. Steel	1,365	28	32	57	46	81	4.2	71	—	613	40	24	9.3	55	—
Vulcan Materials	302	83	87	47	53	64	15.6	14	56	na	—	—	na	—	—
Williams Cos.	831	44	46	68	41	72	8.2	51	78	932	30	35	7.3	62	72
Wilco Chemical	623	56	56	65	44	38	10.5	42	31	271	65	67	24.1	12	13

Note: Companies with negative profitability and those giving only net profits are not included in these rankings. There are 85 companies ranked for operating profit and operating profit margin; 84 companies ranked by assets; and 79 ranked by return on assets. Companies not included in 1983's listing are not ranked for that year. na = not available, def = deficit.

Larger producers outperform smaller

For the second year in a row, the 50 larger chemical producers as a group outperformed the smaller firms in a number of areas.

Riding the wave of economic recovery in 1984, the 50 top producers, largely makers of cyclical large-volume commodity chemicals, saw sales, earnings, and profitability all rise, and in most cases rise faster than those for the 50 smaller producers.

Sales growth for the 50 larger companies averaged 7.7% in 1984 over 1983, whereas that for the smaller producers averaged 6.6%. The difference in earnings growth was even more pronounced. Operating profits from chemicals for the 50 larger com-

panies grew 46% in 1984 compared with just 16% for the group of smaller producers.

The difference between the two groups is somewhat surprising. Although the larger firms are dominated by commodity chemicals, which by their nature are highly dependent on the business cycle, by sometime last year, the smaller producers should have begun to catch up. Add to this the problems that commodity producers have been having with competition from imports, capacity utilization, and pricing, and the difference between the two groups becomes even more important.

The asset base for both groups fell

during 1984. Identifiable chemical assets for the 50 larger firms declined an average of 3.1%; for the smaller producers it dropped 10%.

The rise in operating profits for the larger firms was enough to push the average operating profit margin for the 50 larger firms above that for the smaller firms. Chemical operating profit margins (chemical operating profits as a percentage of chemical sales) for those of the 50 larger firms reporting this figure averaged 9.0% compared with an average of 8.6% for the smaller producers.

The 50 smaller chemical companies, however, maintained their lead in return on assets. Those that reported operating profits from both chemicals and chemical assets averaged a return of 14% on identifiable chemical assets, compared with an average of 12% for the 50 largest producers.

For the Top 100 companies, chemical sales increased 7.6% over the year before, and chemical operating profits were up 41%. The average operating profit margin from chemicals was 9.0%, whereas the average return on identifiable chemical assets was 12%. Identifiable chemical assets for the total group fell 4.0% from 1983.

	Top 50	Second 50	Total 100
Chemical sales, change from 1983	7.7%	6.6%	7.6%
Chemical operating profits, change from 1983	45.9	16.1	40.8
Chemical assets, change from 1983	-3.1	-10.0	-4.0
Chemical operating profit margin, 1984	9.0	8.6	9.0
Return on identifiable chemical assets, 1984	12.1	14.3	12.3
Number of companies on list			
Chemical companies	23	23	46
Petroleum and natural gas producers	13	5	18
Diversified and other	14	22	36
Foreign ^a	5	6	11

^a Also included in above categories.

For the first time, except where there were massive reorganizations, companies in the 1984 ranking are compared with their rankings a year ago, instead of rankings based on restated results in the current annual report. Thus, a rise or fall in rank may well reflect acquired or divested chemical businesses as well as increasing or decreasing sales from operations.

For the second year, C&EN ranks the Top 100 chemical producing firms not only by chemical sales, but by chemical operating profits, operating profit margins, chemical assets, and return on chemical assets.

There are some firsts for companies this year as well. General Electric, long known as a large chemical producer, ranked 15, is new to the list this year. This is the first year that GE has reported chemical sales in such a way that it could be ranked. Also new to the list are Avon, ranked 99, and Crompton & Knowles, 98. Two companies, Northwest Industries, ranked 93, and First Mississippi, 96, have reappeared on the list after an absence. In the case of Northwest Industries, the re-emergence is due to revamped reporting methods that break out chemical sales. First Mississippi returns to the list as the result of much higher sales brought about by improved agricultural markets.

Five companies—Gulf Oil, Esmark, Beatrice Cos., Houston Natural Gas, and Martin Marietta—that were on the 1983 list were dropped in 1984, mostly for reasons other than declining sales. The reasons include acquisition by other firms already on the list, divestiture of chemical operations, and changes in reporting methods that do not allow discernment of chemical operating results.

Again, there are a number of large chemical producers not on the Top 100 list because they do not disclose chemical sales. These include such producers as Procter & Gamble and ICI Americas.

There are companies on the Top 100 list that have chemical sales including large amounts of nonchemical products. Examples are Monsanto, Borden, Ethyl Corp., and American Hoechst.

Acquisitions and leveraged buyouts of chemical operations also are playing a big part in changing the makeup of the Top 100 list. Over the past few years, a number of private firms have been formed that probably would be on the list if they were to disclose their sales. These include such firms as Vista Corp. and LCP Industries, both formed from parts of other chemical operations. □

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News of the Week

■ **Former Hoffmann-La Roche employees sue company on age discrimination charges.** Page 4

■ **New service aims at making Japanese technical information more readily available.** Page 5

■ **Uniroyal to be acquired in leveraged buyout by private New York investment firm.** Page 5

■ **Report on engineering education and practice in the U.S. concludes some serious problems exist.** Page 5

■ **Public Health Service tightens rules providing protection for laboratory animals.** Page 6

■ **EPA asks regional offices to consider alternatives to reburying hazardous wastes.** Page 6

Cover: Ribonuclease, showing those amino acids that are altered by evolution to engineer the protein to be a dimer (green); those involved in adapting the enzyme to be stable enough to survive in the digestive tract (red); and those conserved to permit a defined folding pattern around a hydrophobic core (pink)

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International Business

European chemical companies performed well last year, registering gains in both sales and earnings. Page 13

Government

New engineering research centers are expected to bridge science and technology, train engineers for work in industry. Page 15

Better leak detection systems needed at many toxic waste sites regulated under Resource Conservation & Recovery Act. Page 16

Science

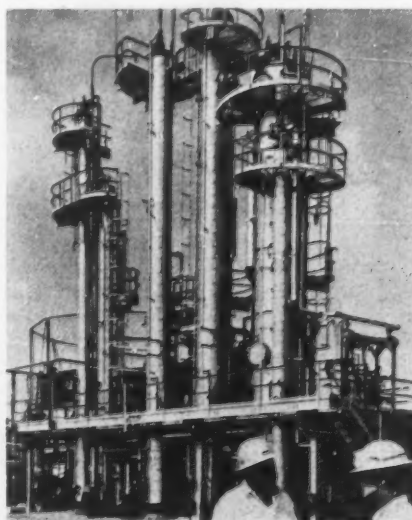
From the ACS meeting: charting evolution of enzyme functions can be a powerful tool for predicting enzyme properties; chemists synthesize molecules whose complexing behavior mimics that of enzymes. Page 18

Technology

From Miami Beach: forest damage from air pollution, a major issue facing industrial societies, needs intensive study; prospects for membrane technology and science are encouraging. Page 23

Books

"The Dragon Hunters" by Frank Graham Jr. pulls together stories of scientists working to control insects biologically. Page 28



Business

Chemical earnings declined for basic chemical producers in the first quarter—a drop for the second straight quarter. Page 8

Chemical Earnings Fell Again in First Quarter

For second straight quarter basic chemical producers show drop from year-earlier period; chemical operations also hurt diversified, oil firms

David Webber, C&EN New York

This year's first quarter turned out to be a letdown for U.S. chemical producers. The dollar, rampaging through the exchange markets, wreaked havoc in chemical markets. Imports, pegged to lower-value foreign currency, swelled in volume, stealing domestic market share and unmanaging price initiatives. Export markets turned a cold shoulder to dollar-based products. Many raw-material costs rose.

The result was a sharp decline in chemical earnings compared to last year's first quarter. For the 30 largest chemical producers, combined net income dropped 24% from a year earlier. The slump was even greater for the 15 largest firms (which account for 86% of total sales of the entire group); their combined net

fell 28%. The smaller 15 companies posted a composite earnings decline of 3% in the quarter. Sales revenues fell 2% for the 15 biggest companies and were unchanged from a year before for the smaller 15.

Softening the harshness of this picture, it must be noted that the period's results are being compared to a very strong first-quarter 1984, the second-strongest three-month span for earnings since the chemical industry began its recovery in the second quarter of 1983. In addition, first-quarter performance when compared with that of the preceding quarter (fourth-quarter 1984) is mixed. Although sales for the group were down a fraction, net income increased 4%. The composite first-quarter 1985 profit margin (after-tax income as a percentage of sales), although down to 4.6% from 5.9% a year earlier, was up from 4.4% in fourth-quarter 1984.

Still, those comparisons do little to qualify the chemical industry's serious problems that cut across most product segments. "There has been no growth in the industrial sector of the economy since mid-1984, due largely to the abnormal strength of

the dollar and the resultant increasing flood of imports, which are now affecting directly or indirectly almost every domestic manufacturing industry," says Edward G. Jefferson, Du Pont's board chairman. "We have seen the impact of the strong dollar on most of our business segments in the form of constrained volume plus price erosion in domestic and international markets."

In the first quarter, Du Pont's earnings, excluding extraordinary and nonrecurring items, were down 41% from the year-earlier period. Sales fell 11% during that time.

The pervasiveness of these problems can be seen, in that 21 of the 30 largest chemical companies reported declines in net income in the first quarter. Eleven of those were among the 15 largest firms. In fourth-quarter 1984, by comparison, 16 companies had lower earnings than in the same period the year before.

Part of the problem is that many of the cost controls implemented in the early 1980s have been exploited to their limits. Some Wall Street analysts believe that, short of drastic measures like further employment

Chemical industry leaders for the first quarter

Sales			Earnings ^a			Profitability		
Rank 1985	\$ Millions	Rank 1984		\$ Millions	Rank 1984	Earnings as % of sales		Rank 1984
1 Dow Chemical	\$2753.0	1	Dow Chemical	\$110.0	2	International Flavors	14.5%	1
2 Union Carbide	2172.0	2	Monsanto	87.0	1	Freeport-McMoRan	12.0	2
3 Monsanto	1624.0	3	Union Carbide	71.0	3	Naico Chemical	10.7	4
4 W. R. Grace	1580.0	4	PPG Industries	70.4	4	Petrolite	9.1	7
5 PPG Industries	1040.0	5	American Cyanamid	45.8	5	Loctite	7.9	3
6 American Cyanamid	959.6	6	Rohm & Haas	40.3	6	Air Products	7.8	8
7 Celanese	748.0	7	Hercules	38.6	7	Lubrizol	7.6	9
8 Hercules	638.0	8	Celanese	36.0	8	Ethyl	7.5	17
9 National Distillers	574.2	9	Air Products	35.6	10	International Minerals	7.4	12
10 Rohm & Haas	552.8	10	Morton Thiokol	32.1	14	Rohm & Haas	7.3	5

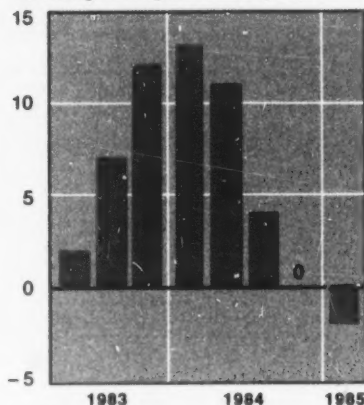
^a After taxes. Note: For 30 companies listed on page 10.

Chemical industry 1985 first-quarter results

- Sales slipped 2%
- Earnings plunged 24%
- Profit margins 4.6%
- Production rose just 1.7%
- Prices edged up 1.2%

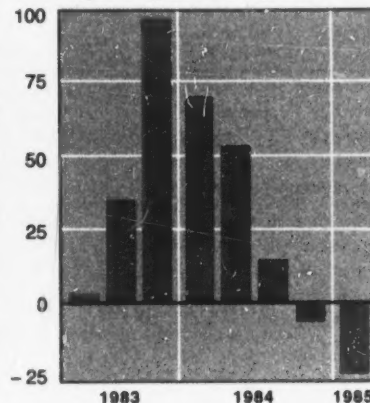
Sales

% change from year-earlier quarter



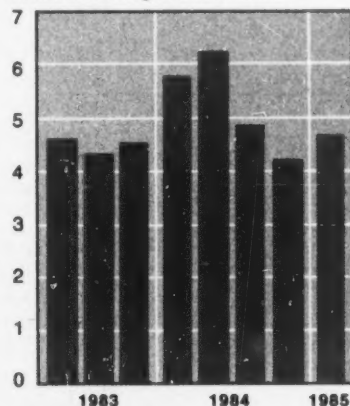
Earnings

% change from year-earlier quarter



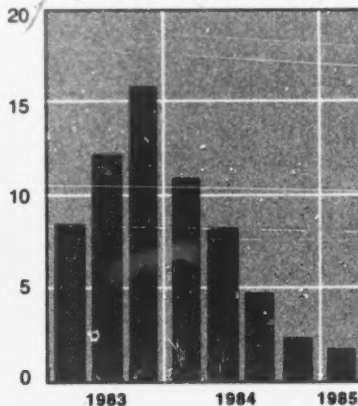
Profit margins

After-tax earnings as % of sales



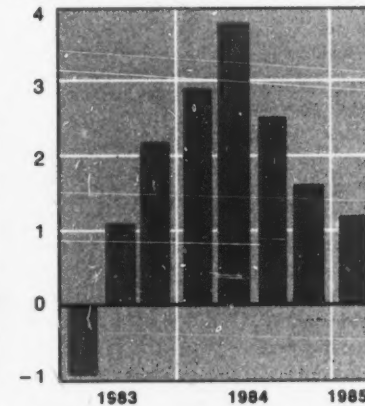
Production

% change from year-earlier quarter



Prices

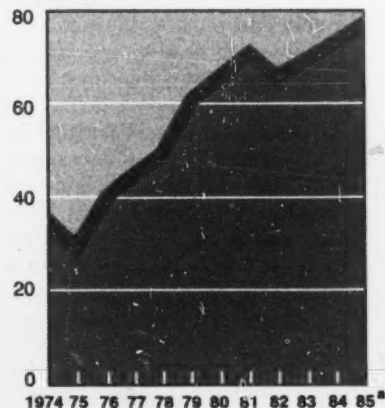
% change from year-earlier quarter



Sales in 1985 will rise 4% and earnings will increase 9%, moving chemical profitability to 5.4%

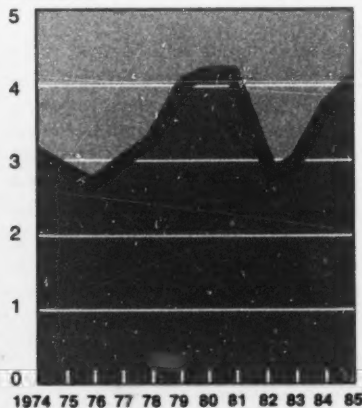
Annual sales

\$ Billions



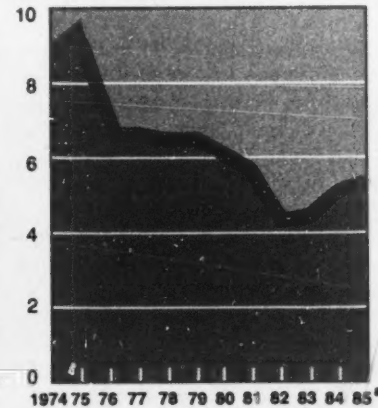
Annual earnings

\$ Billions



Annual profit margins

After-tax earnings as % of sales



■ C&EN estimates. Note: All sales, earnings, and profit-margin data are based on combined results of the 30 companies listed on page 10.

Average earnings for largest chemical producers fell 24% in first quarter

	FIRST-QUARTER 1985						12-MONTH RUNNING DATA			
	Sales	Earnings ^a	Change from 1984		Profit margin ^b		Change from 1984		Profit margin ^b	
	(\$ millions)		Sales	Earnings	1985	1984	Sales	Earnings	1985	1984
Air Products ^c	\$ 457.7	\$ 35.6	1%	-3%	7.8%	8.1%	4%	11%	7.8%	7.4%
American Cyanamid ^c	959.6	45.8	2	-19	4.8	6.0	6	0	5.1	5.4
Celanese ^c	745.2	36.0	-11	-18	4.8	5.3	-3	2	4.7	4.5
Chemed	86.2	4.0	9	-20	4.5	6.1	21	3	5.4	6.4
Chesebrough-Pond's ^c	515.9	18.9	23	1	3.7	4.4	14	2	6.1	6.9
Crompton & Knowles	55.7	1.2	-7	-33	2.2	3.0	-4	7	3.2	2.9
Dow Chemical ^c	2,753.0	110.0	-6	-17	4.0	4.5	-1	22	4.2	3.4
Essex Chemical	45.5	2.4	15	25	5.3	4.8	10	168	5.5	2.3
Ethyl	377.4	28.2	-10	14	7.5	5.9	-8	18	8.2	6.4
First Mississippi	68.2	3.9	-5	-18	5.7	6.6	14	74	7.3	4.8
Freeport-McMoRan	214.6	25.7	6	16	12.0	10.9	9	7	11.8	12.0
H. B. Fuller	108.6	1.8	4	-17	1.6	2.0	5	-6	2.8	3.2
W. R. Grace ^c	1,580.0	-4.3	6	def	def	2.3	7	-8	2.1	2.5
Hercules ^c	638.0	38.6	3	-19	6.1	7.7	3	13	7.4	6.8
International Flavors	121.3	17.6	-2	-6	14.5	15.2	2	-1	14.4	14.9
International Minerals ^c	413.3	30.7	7	15	7.4	6.9	9	9	6.1	6.1
Loctite	54.0	4.3	-14	-35	7.9	10.5	0	-2	10.0	10.2
Lubrizol	255.6	19.4	20	15	7.6	8.0	8	10	7.9	7.7
Monsanto ^c	1,624.0	87.0	-6	-50	5.4	10.1	1	-21	5.3	6.8
Morton Thiokol ^c	496.9	32.1	4	28	6.5	5.3	3	1	6.2	6.3
Nalco Chemical	164.2	17.6	-1	2	10.7	10.4	1	2	10.6	10.5
National Distillers ^c	574.2	20.5	-3	-46	3.6	6.4	-8	-31	2.5	3.3
Olin ^c	540.3	15.6	3	-43	2.9	5.2	5	1	3.7	3.8
Pennwalt	261.4	6.7	2	-29	2.6	5.7	6	-1	4.5	4.8
Petrolite	77.5	7.1	7	18	9.1	8.2	4	24	9.0	7.5
PPG Industries ^c	1,040.0	70.4	0	-5	6.8	7.1	10	14	7.4	7.1
Reichhold Chemicals	185.1	2.5	-12	-55	1.3	2.6	0	-2	2.9	3.0
Rohm & Haas ^c	552.8	40.3	1	-28	7.3	10.3	4	-5	7.6	8.4
Union Carbide ^c	2,172.0	71.0	-9	-34	3.3	4.5	1	8	3.6	3.3
Witco Chemical	365.1	11.0	0	-25	3.0	4.0	5	3	3.9	3.9
Total 15 largest companies	\$15,065.7	\$648.1	-2%	-28%	4.3%	5.8%	3%	2%	4.7%	4.8%
Second 15 companies	\$ 2,442.8	\$153.3	0%	-3%	6.3%	6.4%	3%	9%	7.0%	6.6%
GRAND TOTAL	\$17,508.5	\$801.4	-2%	-24%	4.6%	5.9%	3%	3%	5.1%	5.0%

^a Excludes all significant extraordinary and nonrecurring items. ^b After-tax income as a percentage of sales. ^c One of 15 largest firms. def = deficit.

Ground rules for C&EN earnings analysis

C&EN's quarterly report on financial performance of the U.S. chemical industry contains data from the 30 largest U.S. basic chemical companies and from 41 oil and diversified companies, each with more than \$200 million in annual chemical sales.

To be included in the table of basic chemical producers, a company must have at least 40% of its sales in chemicals, and its chemical operations must be the largest single portion of the company's operations. That is why Du Pont, for example, is included in the table of diversified manufacturers.

In referring to chemical sales, C&EN means those chemicals whose molecular composition has been changed in the course of manufacture. Hence, chemical sales include those of traditional categories of basic petrochemicals and inorganics, organic intermediates and inorganic compounds, polymers such as plastics and fibers, agricultural chemicals, and specialty derivatives.

In listing earnings, the survey gives after-tax income for continuing operations before nonrecurring items and extraordinary charges. Foreign currency translations are included.

reductions, many chemical producers probably have lowered their breakeven points about as much as possible for now. Some companies are taking drastic measures. Du Pont, for instance, took a \$125 million after-tax charge to earnings in the first quarter to pay for its latest early retirement program. Some 11,500 employees resigned. And Hercules took a \$2.8 million after-tax charge to cover the expenses of an early retirement program aimed at reducing the staff of Hercules Specialty Co.

Some companies found other ways to shore up the bottom line. Dow Chemical, for example, mined a silver lining in the exchange rate cloud. "Excellent currency manage-

ment during the period made a significant contribution to first-quarter performance," says Dow president Paul F. Orefice. Dow's gain on foreign currency transactions in the first quarter amounted to \$33 million, compared with \$14 million in the year-earlier period.

Still, none of this is making money from chemicals. That was a tougher row to hoe. The impact of the industry's big problems can be sensed in various statistics (applying to the entire chemicals and allied products sector): Production in first-quarter 1985 was just 1.7% above that in the year-earlier period, by far the smallest increase since the end of the recession in late 1982; and chemical prices rose a mere 1.2%, the smallest year-to-year quarterly gain since the recovery began.

Not surprisingly, therefore, the commentary accompanying earnings statements this quarter is pretty much a litany of a few bright spots and many sore spots. Both Air Products and Union Carbide, for instance, point out the good performance of the industrial gases business in the first quarter. Air Products, for which gases accounted for 57% of sales revenue in the quarter, was aided materially; it got through the period with a 1% gain in sales and a 3% decline in net income. There was less impact on Union Carbide's bottom line; industrial gas sales rose 5% but accounted for just 18% of corporate sales. However, whereas Air Products posted a gain in operating income for industrial gases, Carbide reported an 11% decline in that category.

There were many more sore spots. Producers suffered greatly from their inability to raise prices of low-density and high-density polyethylene. National Distillers & Chemical, for example, recorded a 3% decline in sales and a 46% drop in earnings, principally attributable to depressed polyethylene prices in the company's U.S. Industrial Chemicals unit, comments National Distillers' chairman Drummond C. Bell. And InterNorth's Norchem unit (formerly Northern Petrochemical) turned in a \$2.1 million loss for the quarter. Reason: lower LDPE and linear LDPE prices.

Other polymers were in trouble,

Earnings for energy and diversified firms fell 15%

FIRST-QUARTER 1985									
	% chemical sales	Sales		Earnings ^a		Change from 1984		Profit margin ^b	
		(\$ millions)				Sales	Earnings	1985	1984
OIL AND GAS COMPANIES									
American Petrofina	15%	\$ 566.1	\$ -2.7	3%	def	def	1.9%		
Amoco ^c	10	7,000.0	473.0	-7	-20%	6.8%	7.9		
Ashland Oil	14	1,800.0	14.1	-10	182	0.8	0.3		
Atlantic Richfield	10	5,819.0	352.0	-10	-15	6.0	6.3		
Chevron	4	12,600.0	354.0	73	-6	2.8	5.2		
Diamond Shamrock	21	954.7	59.1	-16	-1	6.2	5.2		
Exxon	7	23,099.0	1325.0	-7	-10	5.7	5.9		
InterNorth	5	2,900.1	113.9	76	-15	3.9	8.2		
Kerr-McGee	13	809.3	28.4	-10	-29	3.5	4.5		
Mobil	4	15,363.0	320.0	2	-16	2.1	2.5		
Occidental Petroleum	7	3,700.0	16.3	-5	-85	0.4	2.7		
Phillips Petroleum	15	4,020.0	120.0	2	-38	3.0	4.9		
Shell Oil	16	4,743.0	296.0	-4	-9	6.2	6.6		
Standard Oil (Ohio)	5	3,198.0	343.0	10	-10	10.7	13.2		
Sun Co.	3	3,670.0	127.0	-13	-11	3.5	3.4		
Tenneco	7	3,719.0	63.0	-4	-59	1.7	4.0		
Texaco	2	12,000.0	320.0	11	0	2.7	3.0		
Unocal (Union Oil)	10	2,800.0	180.7	4	0	6.5	6.7		
DIVERSIFIED MANUFACTURERS									
Allied	22	2,800.0	134.0	0	1	4.8	4.8		
Aluminum Co. of America	4	1,313.9	6.7	-11	-92	0.5	5.6		
Borden	28	1,077.4	34.8	-2	3	3.2	3.1		
Borg-Warner	21	939.3	44.6	-1	-11	4.7	5.3		
Du Pont	32	8,259.0	221.0	-11	-41	2.7	4.0		
Eastman Kodak	21	2,127.1	115.2	-1	-27	5.4	7.4		
Engelhard	23	575.2	11.7	-11	def	2.0	def		
FMC	39	755.8	44.0	-14	-8	5.8	5.4		
General Electric	7	6,200.0	511.0	-6	5	8.2	7.4		
Georgia-Pacific	10	1,580.0	49.0	6	14	3.1	2.9		
B. F. Goodrich	35	798.7	2.3	-7	-77	0.3	1.2		
Kaiser Aluminum	18	816.6	-18.5	17	def	def	2.7		
Koppers	45	353.7	-13.0	2	def	def	def		
Eli Lilly	23	908.8	160.9	2	10	17.7	16.4		
3M	15	1,906.0	164.0	2	-6	8.6	9.3		
Merck	17	856.3	131.5	1	5	15.4	14.7		
NL Industries	35	327.4	4.4	4	422	1.3	0.3		
Pfizer	10	945.7	147.3	3	15	15.6	13.9		
Tyler	33	219.3	1.8	1	-54	0.8	1.8		
Uniroyal	28	508.0	21.0	0	5	4.1	3.9		
U.S. Steel	6	4,500.0	-13.0	-6	def	def	0.6		
Upjohn	13	545.5	51.6	-3	-21	9.5	11.5		
Vulcan Materials	26	203.5	5.0	1	-26	2.5	3.3		

a From continuing operations excluding nonrecurring and extraordinary items. b Earnings as a percentage of sales. c Formerly Standard Oil (Ind.). def = deficit.

too. For Celanese, earnings of the fibers group (the company's largest product group) dropped 29% because of such factors as lower export prices for smoking products and soft demand for acetate filament and polyester staple. Monsanto's operating earnings for its fibers and intermediates unit fell 86%, and those for

polymer products fell 53%, both before taxes. As for Du Pont, after-tax operating income fell 52% for fibers and 20% for polymer products.

Industrial chemicals gave even less help to earnings. Du Pont's agricultural and industrial chemicals segment recorded a 55% earnings decline, and Celanese's chemical

product group earnings dropped 38%. Monsanto's industrial chemicals operating income fell 67%. Both Olin and PPG Industries say their industrial chemicals earnings were well below those in the year-earlier quarter, and Union Carbide recorded a 40% decline in operating profit for its petrochemicals segment.

Lower earnings were reported for fertilizer operations, too. For example, W. R. Grace's agricultural chemicals operations produced a \$4.8 million loss in the first quarter, caused

by lower prices for phosphate fertilizers. International Minerals & Chemical, one of the few companies to have higher earnings for the quarter, was hurt by pricing for potash and phosphate products.

Participating in widespread agriculture problems, even herbicides earnings were down in general. Operating income of Monsanto's agricultural products unit fell 21%. Chief executive Richard J. Mahoney says that first-quarter Roundup herbicide shipments in the U.S. were below

earlier expectations because distributors were expecting farmers to delay discretionary uses of Monsanto's biggest money-maker.

Morton Thiokol shut down its Weeks Island, La., herbicide plant, where a history of inadequate profitability was capped by the cutoff of supplies of methyl isocyanate—an ingredient in Morton Thiokol's product—when Union Carbide temporarily shut down its Institute, W. Va., MIC unit following the disaster in Bhopal, India, involving that chemical. "The future uncertainties associated with obtaining and transporting the MIC to Weeks Island do not warrant continued production of the herbicide," Morton Thiokol says.

Rohm & Haas, on the other hand, posted a 10% increase in net income for its agricultural chemicals segment. The company cites strong pre-season shipments of two of its herbicides as the reason.

Generally dissatisfied with their companies' performance in the first quarter, chief executives are expressing little more than muted confidence about the rest of the year. They are concerned over the direction in which the overall economy is heading, and generally expect that full-year 1985 earnings will not increase so much as 1984 earnings did. Still, most executives believe their firms' performance will improve over the first quarter in coming periods this year.

Forecasts for the rest of the year are correspondingly moderate. "IMC has previously forecast an increase of 5 to 10% in net earnings for fiscal 1985 over 1984," says president George D. Kennedy. "Given a reasonable spring fertilizer season and some firming of prices, a result on the low side of that range appears likely." Grace expects the first quarter to be the low point of the year, and at Olin, chairman John M. Henske expects "overall performance for the year to be below that of 1984."

Similarly, PPG chairman Vincent A. Sarni says, "For the remainder of the year, because of a slowing in some of our key markets—particularly chemicals—improving on our 1984 level of performance will be a real challenge." □

Energy companies' chemical earnings fell, too

Oil and gas producers, already wounded by the poor conditions of the petroleum marketplace, found no balm in the performance of their chemical operations in the first quarter. After-tax earnings for the chemical segments of seven oil companies that break out such data fell across the board a composite total of 43% compared with the first quarter of 1984.

Most chemical products marketed by the major oil firms are commodity petrochemicals, which have been most affected by the stagnation that has characterized much of the chemical pricing structure for more than a year. In their explanations for the chemical segments' poor results, in fact, energy company chief executives point almost uniformly to slimmer margins and the effects of the strong dollar as the chief causes of the decline.

"Depressed margins, particularly in commodity petrochemicals, reduced U.S. earnings," says Clifton C. Garvin Jr., chairman of Exxon, which has the largest chemical sales among energy companies. "Foreign earnings were down \$23 million, as the effect of lower margins was only partially off-

set by slightly higher sales volumes and a gain from the sale of a fertilizer facility in Europe."

Amoco notes that lower margins more than countered the positive impact of increased sales volume in most product lines, and Shell says the principal factor in its chemical earnings decline was lower refined product selling prices.

"Earnings from chemical operations were affected by the strong U.S. dollar, which depressed export volumes and increased imports in [first-quarter] 1985," says William F. Kieschnick, president of Atlantic Richfield. "Profit margins were generally lower, reflecting increased competition."

Mobil blames startup expenses for its petrochemical plant in Saudi Arabia as the primary cause for the loss registered by its chemical segment in the first quarter. Earnings in the U.S. were essentially unchanged, Mobil says, because lower petrochemical margins were largely offset by improved profits in the company's plastics businesses. InterNorth's Norchem unit, which also recorded a loss, pins the blame on lower prices for low-density and linear low-density polyethylene.

Chevron, citing increased sales of agricultural chemicals and fertilizers, reported an increase in chemical segment earnings to \$20 million from \$7 million last year. But this year's figure includes results of the Gulf operations acquired last year, whereas the first-quarter 1984 figure does not. Factoring in Gulf's \$49 million in chemical earnings for first-quarter 1984 means Chevron's chemical segment earnings actually declined 64% in the first quarter of 1985.

\$ Millions	First-quarter earnings on chemical operations ^a		
	1985	1984	% change
Amoco ^b	\$49.0	\$59.0	-17%
Atlantic Richfield	15.0	17.0	-12
Chevron	20.0	56.0 ^c	-64
Exxon	80.0	121.0	-34
InterNorth	-2.1	5.3	def
Mobil	-7.0	13.0	def
Shell	13.0	21.0	-38

^a After-tax earnings. ^b Formerly Standard Oil (Ind.). ^c Restated to include Gulf first-quarter 1984 results. def = deficit.

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MAY 20, 1985

CHEMICAL & ENGINEERING

More scientific news from
ACS Miami Beach meeting

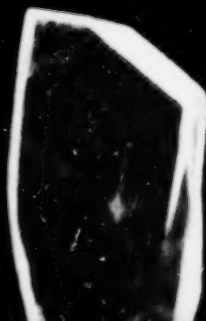
NEWS



Solid Ion Conductors

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News of the Week

■ **Allied Corp. and Signal Cos. merge to form company with annual sales of almost \$17 billion.** Page 4

■ **U.S. production of aerosol units rose 5% in 1984.** Page 5

■ **Phillips Petroleum is licensing new yeast recombinant DNA expression system.** Page 5

■ **BASF America will buy automotive paints and ink producer Inmont for \$1 billion.** Page 5

■ **Judge rules U.S. government not liable to contribute to industry settlement with Vietnam veterans in agent orange suit.** Page 6

Cover: Crystal of β -alumina in which sodium content has been replaced by europium(II) glows yellow-green when illuminated by ultraviolet light. When the sodium is replaced by terbium(III), the crystal glows blue; when replaced by europium(III) reddish purple

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Business

Dionex hopes to keep a step ahead of the big boys by improving its lead in the ion chromatography market; U.S. polymer production climbed to its highest point ever in 1984. Page 9

International Business

Chemical business executives in Canada see a rosy future, survey finds—employment, sales, and profits all on the rise. Page 14

Government

Federal agencies announce plans of action for the coming year, including proposed regulations. Page 18

Science

From the ACS meeting: studies of gas-phase ions proving richly rewarding; inflammation changes lung cell metabolism; society promoting joint catalysis programs with U.S.S.R. and China. Page 21

Symposium on polymers, honoring Herman Mark on his 90th birthday, drew four Nobel Laureates among the dignitaries. Page 32

Technology

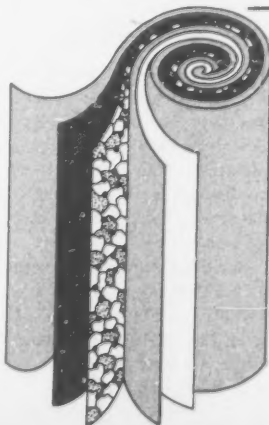
From Miami Beach: computer models help track hazards of fires; mechanisms given for different LC-MS methods; criminalist charges that forensic laboratories are unreliable. Page 35

ACS News

ACS Council tightens eligibility requirements for members with emeritus and retired status, raises dues. Page 61

Special Report

Solid ionic conductors are unusual materials that researchers see uses for in high-energy-density batteries, lasers, and phosphors. Page 42



Polymer output reached new high in 1984

David Webber, C&EN New York

Coming off a good year in 1983, aggregate polymer production rose to its highest point ever in 1984. At just under 50 billion lb, the composite total for output of plastics, synthetic fibers, and synthetic rubber surpassed the previous record of 47.6 billion lb reached in 1979. By erasing the downturns of the early 1980s, the surge lifted the composite compound growth rate for all major polymers to an annual average 3.5% for the past 10 years.

Still, the totals mask the shortfall of last year's synthetic fibers output of 9.4 billion lb not only from the record set in 1979, but from output reported for 1978, 1980, and 1981 as well. And 1984 production of synthetic rubber, though growing more than that for either of the other two polymer groups, remained well below levels of a decade earlier. Only plastics production, at 35.6 billion lb last year, topped its previous record of 33.1 billion lb in 1983.

At about 8% (all plastics statistics based on data from the Society of the Plastics Industry), last year's increase in plastics output fell short of the 15% jump registered in 1983 over recession year 1982. However, it was a respectable rise for the second leg of the business cycle's upward swing. The thermoplastic res-

ins segment, which accounted for about 84% of plastics production in 1984, grew 8% from 1983, paced by output of polyvinyl chloride (and its copolymers) and polypropylene (and its copolymers), both of which climbed 11%.

PVC production was especially spurred by a 28% jump in demand for PVC pipe and tubing, a segment that alone accounted for 43% of PVC consumption last year. For polypropylene producers, the pace was set by consumption increases of 10% for the fibers and filaments segment (27% of the market) and substantial growth in the smaller transportation, appliance, and sheet-areas.

More-moderate increases in production were registered by polystyrene—aided by a 34% jump in exports and good demand growth from markets in disposables, expandable beads, and furniture and furnishings—and high-density polyethylene, whose sales and use in the important blow-molding area (35% of the market) increased 14% to 2.08 billion lb. On the other hand, HDPE's other substantial application, injection molding, grew less than 1% between 1983 and 1984.

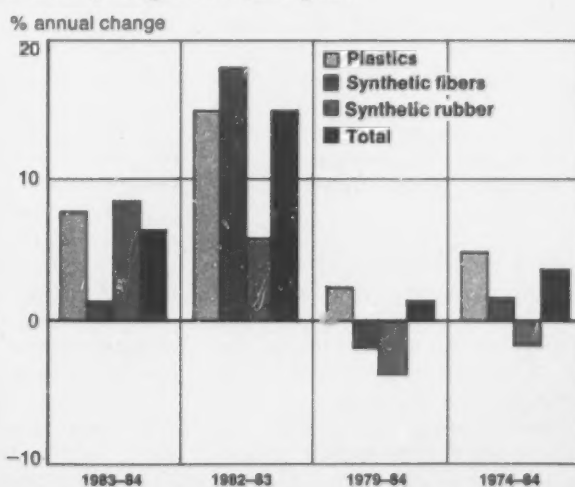
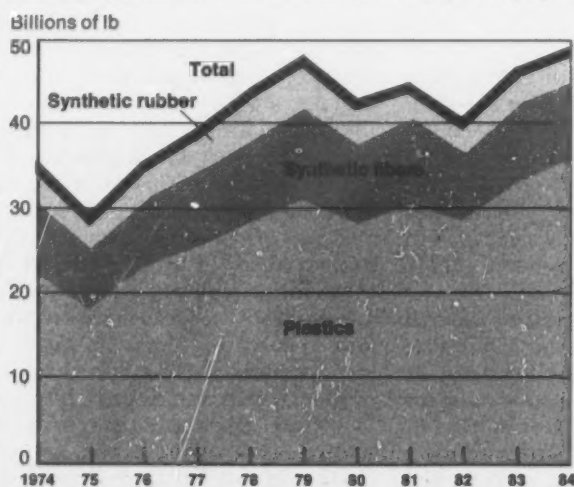
Output of low-density polyethylene was held to a 5% rise because consumption for film (58% of the market) was nearly level with the

year before. LDPE's performance was mixed. On the one hand, consumption of LDPE in injection molding declined nearly 7% to 612 million lb. Conversely, its use in extrusion coating, the other sizable application, increased 12% to 640 million lb in 1984.

The 6% rise in thermoset production last year was paced by epoxy resins, which benefited from a 17% jump in use in protective coatings (40% of the market); by polyester resins, with strong consumption gains in almost all applications; and by melamine resins, a small component. Output of the largest thermoset, phenolic resin, grew minimally, held down by flat demand from the plywood industry (52% of the market) and a sharp drop in use in insulation (14% of the market).

Output of plastic resins undoubtedly would have been higher had it not been for a widespread decline in export volume, a result of the powerful dollar. Exports of high-density polyethylene, for example, fell to 696 million lb in 1984 from 1 billion lb the year before, a decline of some 30%. Similarly, exports of PVC dropped to 379 million lb, a one-year slide of some 29%. Other losers included polypropylene, exports of which dipped 2% to 782 million lb, and unsaturated polyes-

Plastics, rubber contributed most to 6% polymers output growth last year



Total polymers production approached 50 billion lb last year

	Billions of lb		Common units					Average annual growth			
	1984	1983	1984	1983	1982	1979	1974	1983-84	1982-83	1979-84	1974-84
PLASTICS (millions of lb)											
Thermosetting resins	5.55	5.25	5,549	5,254	4,367	4,856	3,514	5.6%	20.3%	2.7%	4.7%
Phenol and other tar acid resins	2.50	2.48	2,502	2,484	2,060	1,781	1,355	0.7	20.6	7.0	6.3
Urea resins	1.20	1.17	1,199	1,172	998	1,367	835	2.3	17.4	-2.6	3.7
Polyesters (unsaturated)	1.23	1.08	1,232	1,084	865	1,147	911	13.7	25.3	1.4	3.1
Epoxies (unmodified)	0.41	0.33	406	334	286	361	249	21.6	16.8	2.4	5.0
Melamine resins	0.21	0.18	210	180	158	200	164	16.7	13.9	1.0	2.5
Thermoplastic resins	30.04	27.80	30,036	27,799	24,425	26,768	19,273	8.0%	13.6%	2.3%	4.5%
Low-density polyethylene	8.41	8.04	8,413	8,041	7,503	7,793	5,973	4.6	7.2	1.5	3.5
PVC and copolymers	6.78	6.07	6,760	6,066	5,326	6,119	4,850	11.4	13.9	2.0	3.4
High-density polyethylene	5.09	5.69	6,085	5,691	4,928	5,010	2,837	6.9	15.5	4.0	7.9
Polystyrene ^a	3.84	3.57	3,838	3,567	3,191	4,005	3,364	7.6	11.8	-0.8	1.3
Polypropylene, copolymers	4.94	4.43	4,940	4,434	3,477	3,841	2,249	11.4	27.5	5.2	8.2
TOTAL^b	35.59	33.05	35,585	33,053	28,792	31,624	22,787	7.7%	14.8%	2.4%	4.6%
SYNTHETIC FIBERS (millions of lb)											
Cellulosics	0.59	0.60	587	603	551	930	1,199	-2.7%	9.4%	-8.8%	-6.9%
Rayon	0.39	0.38	389	375	355	606	817	3.7	5.6	-8.5	-7.2
Acetate ^c	0.20	0.23	198	228	196	324	382	-13.2	16.3	-9.4	-6.4
Noncellulosics	8.82	8.71	8,823	8,705	7,341	9,433	6,908	1.4%	18.6%	-1.3%	2.5%
Polyester	3.39	3.54	3,392	3,543	3,168	4,178	2,934	-4.3	11.8	-4.1	1.5
Nylon ^d	2.41	2.42	2,412	2,418	1,927	2,721	2,126	-0.2	25.5	-2.4	1.3
Glass fiber ^e	1.35	1.17	1,351	1,167	899	1,014	683	15.8	29.8	5.9	7.1
Olefin	1.00	0.91	997	906	723	759	531	10.0	25.3	5.6	6.5
Acrylic ^f	0.67	0.67	671	671	624	761	634	0.0	7.5	-2.5	0.6
TOTAL^b	9.41	9.31	9,410	9,308	7,892	10,363	8,107	1.1%	17.9%	-1.9%	1.5%
SYNTHETIC RUBBER (thousands of metric tons)											
Styrene-butadiene ^g	2.11	1.99	958	904	876	1,378	1,466	6.0	3.2	-7.0	-4.2
Polybutadiene	0.79	0.73	359	333	288	397	310	7.8	15.6	-2.0	1.5
Ethylene-propylene	0.47	0.39	215	175	123	175	126	22.9	42.3	4.2	5.5
Neoprene	0.29	0.25	130	115	119	183	163	13.0	-3.4	-6.6	-2.2
Nitrile	0.15	0.12	67	55	45	75	88	21.8	22.2	-2.2	-2.7
Other ^h	0.81	0.78	368	353	378	319	346	3.7	-6.6	2.8	0.6
TOTAL^b	4.62	4.27	2,095	1,935	1,829	2,527	2,499	8.3%	5.8%	-3.7%	-1.7%

^a No longer includes acrylonitrile-butadiene-styrene or styrene-acrylonitrile resins; previous years' figures are restated. ^b Totals are for those products listed. Totals may not add because of rounding. ^c Includes diacetate and triacetate yarn; does not include cigarette filters. ^d Includes aramid. ^e Total for 1984 estimated from nine months' data. ^f Includes modacrylic. ^g Excludes high-styrene latex. ^h Includes butyl, polyisoprene, chlorosulfonated polyethylene, polyisobutylene, and acrylo, fluoro, polysulfide, and silicone elastomers. Sources: Society for the Plastics Industry, Textile Economics Bureau, Rubber Manufacturers Association.

ter resins, exports of which fell 18% to 8 million lb in 1984.

Exports did not decrease in all cases, however. Shipments overseas of low-density polyethylene, for instance, increased 6% from 1983 to 974 million lb. Among smaller-volume products, exports of phenolic resins swelled 36% to 22 million lb last year, and exports of epoxy resins jumped 18% to 41 million lb.

Producers of synthetic fibers spent 1984 trimming production runs in response to the swelling rise of cheaper imports. Having climbed an average of 19% per year since 1981, textile and apparel imports

jumped another 32% last year—spurred largely by the continued strength of the dollar against other currencies—and were the chief cause for declines in output of the two biggest fiber segments, polyester and nylon, down 4% and less than 1%, respectively (statistics from the Textile Economics Bureau). With the help of strong gains by glass and olefin fibers (25% of all fibers output), the noncellulosics area managed a 1% rise in production last year. Cellulosics output, which has been shrinking overall during the past 10 years, diminished in 1984 after rebounding strongly the year before.

Synthetic rubber followed its 1983 rebound from the recession with another increase in 1984, raising production another 8%. The largest segment, styrene-butadiene rubber (46% of all synthetic rubber output last year), increased production a solid 6% last year. That was not enough, however, to overcome the product's long-term decline. Over the past 10 years, SBR production has fallen at an annual compound rate of about 4%.

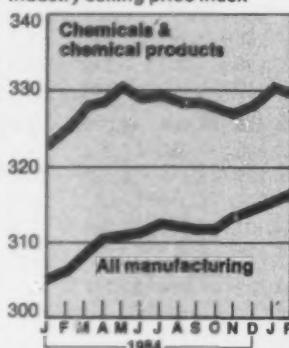
The best performers in the rubber segment last year, in terms of production, were ethylene-propylene rubber—output up 23%—and nitrile rubber—output up 22%. □

Canadian Chemical Execs Are Optimistic

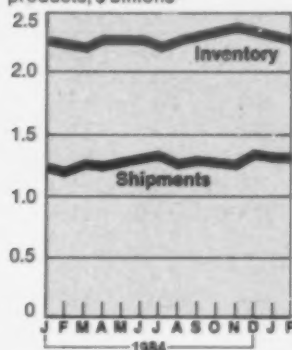
Volume index, gross domestic product^a



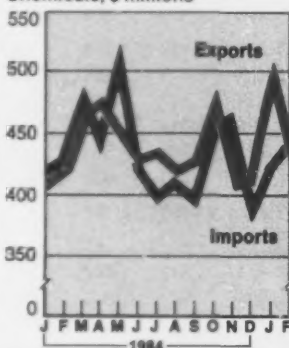
Industry selling price index^b



Chemicals and chemical products, \$ billions^c



Chemicals, \$ millions^c



^a Seasonally adjusted, 1971 = 100. ^b 1971 = 100. ^c Canadian dollars.
Source: Statistics Canada

Chemical output has some weak spots

Production, thousands of metric tons	1984	First two months 1985	1984	% change 1982-84
ORGANICS				
Ethylene	1464	291	214	36.0%
Propylene	665	104	109	-4.6
Benzene	557	86	103	-16.5
Toluene	430	69	69	0
Xylene	417	70	74	-5.4
PLASTICS				
Polyethylene, low density	529	109	78	39.7
Polyethylene, high density	227	39	27	44.4
Polyvinyl chloride	252	45	41	9.8
INORGANICS				
Hydrochloric acid	161	27	25	8.0
Nitric acid	1100	183	183	0
Phosphoric acid ^a	891	120	136	-11.8
Sulfuric acid	4053	664	771	-13.9
Ammonia, anhydrous	3493	579	584	0.9
Ammonium phosphate	1383	242	251	-3.6
Chlorine	1424	239	223	7.2
Sodium hydroxide	1575	261	245	6.5

^a 100% P₂O₅. Source: Statistics Canada

Canadian business executives now are more confident about the near-term economic outlook for Canada, according to a recent survey conducted by the Conference Board of Canada. The majority of the executives surveyed see lower unemployment, stronger sales, and improved profits lying ahead, at least for the next six months.

Compared to the results of a similar survey conducted late last year, fewer executives say that their investment plans are affected adversely by high interest rates and labor costs. Fewer, too, view weak market demand as a major deterrent to more investment.

The results of this latest Conference Board survey reflect well the attitude within the Canadian chemical industry. "Optimistic" is the word most chemical industry leaders are using to describe how they feel about the foreseeable future. This despite the fact that there are, indeed, weak spots in the market. And, during the first quarter, some Canadian chemical companies didn't fare so well on the bottom line as they did in the first quarter of 1984.

Early production results are a mixed bag. During the first two months of the year, ethylene and some of its major derivatives scored impressive advances. This, of course, is because Alberta Gas Ethylene's second ethylene plant—a 680,000 metric-ton-per-year unit—went on stream late last year and several large derivatives units followed it into operation.

Elsewhere, the record is not so rosy. Aromatics output was down during the first two months. Several major inorganics, particularly those related to fertilizer, took a nosedive.

Despite these scattered early setbacks, Canadian chemical executives, particularly those in the petrochemical sector, have good reason to be optimistic. That good reason is the so-called "Western Accord"—the energy agreement signed in late March between the federal government and three western energy-producing provinces.

The accord will steer the chemical industry's basic feedstocks toward more "market responsive" pricing, something that a petrochemical industry task force recommended more than a year ago. It eliminates many of the onerous up-front taxes and special charges, contained in the old National Energy Plan (NEP), that raised havoc with company profits for so long.

W. Norman Kissick, chairman of Union Carbide Canada, says that he is "cautiously optimistic" about the effects of the Western Accord on oil and gas pricing. His firm, hurt more than most by NEP pricing policies, has been a leader in the campaign to get relief from taxes on feedstock. He wonders, however, if some of the front-end charges that are scheduled to disappear on June 1 may reappear in some other form.

Earl Anderson, New York

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Chemical capacity use
flat in first quarter Page 24
Dioxins in the environment
probed Page 41

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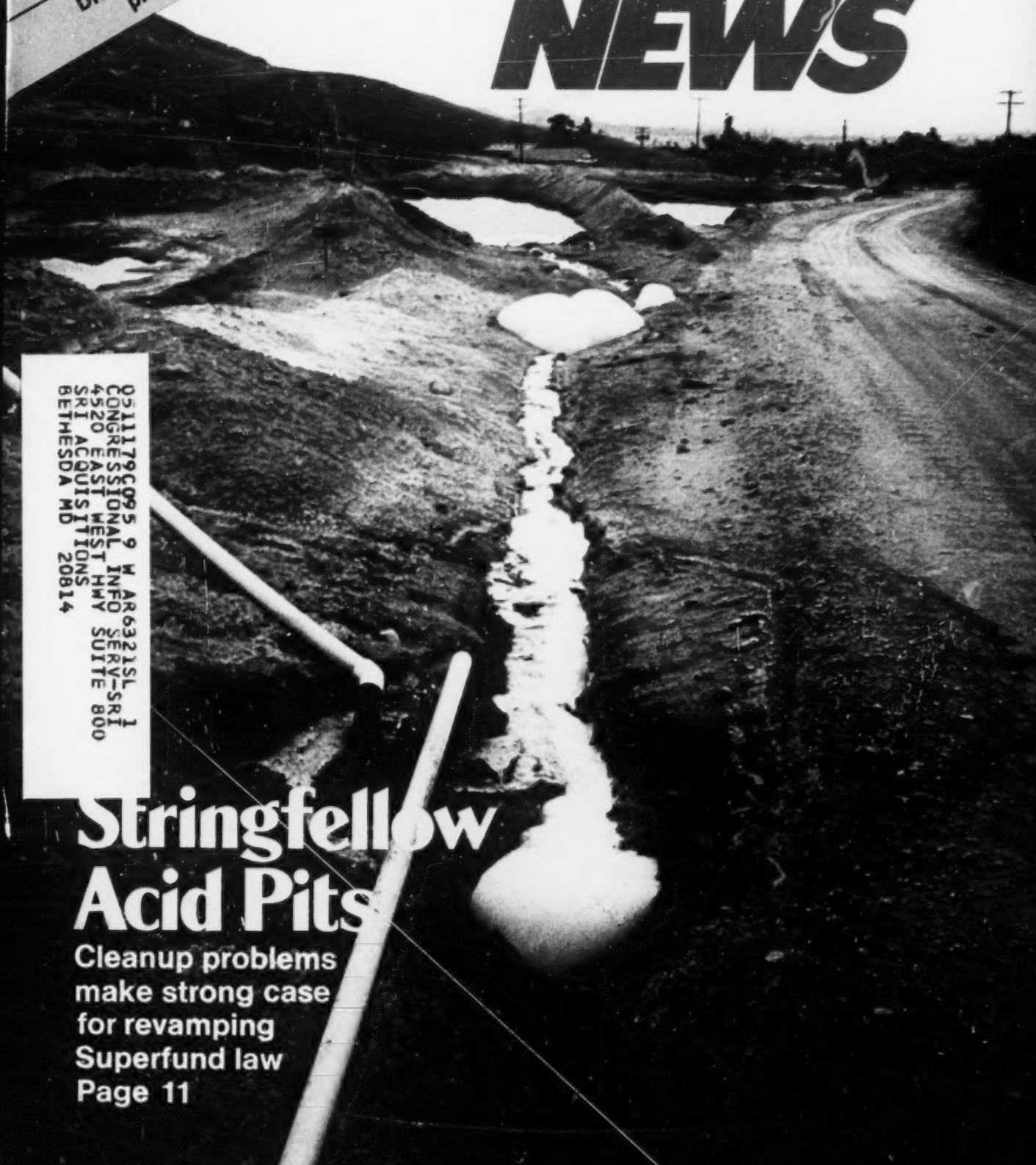
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Stringfellow Acid Pits

Cleanup problems
make strong case
for revamping
Superfund law
Page 11



News of the Week

■ **House trio introduces bill to force EPA regulation to cut air emissions of 85 industrial chemicals.** Page 6

■ **Allied and Signal probably will sell some of their businesses after they merge.** Page 7

■ **EPA agreement with Westinghouse requires company to clean up six PCB-contaminated waste sites in Indiana.** Page 7

■ **Italian appeals court drops or reduces charges against company executives involved in dioxin disaster in Seveso in 1976.** Page 7

■ **Funding support for binary arms squeaks by Senate.** Page 8

■ **Studies link oncogene N-myc to resistance to cancer therapy.** Page 8

Cover: Stringfellow acid pits in Glen Avon, Calif., in 1978 before clay cap was placed over open evaporation ponds. Photo courtesy of EPA

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Business

U.S. chemical plant capacity use in the first quarter is about level with that of third-quarter 1984. Page 24

International Business

Switzerland's Lonza and U.K.'s Fine Organics aim to specialize in areas unattractive to big producers to boost sales. Page 30

Government

Both houses of Congress propose freezing, or reducing, federal government's research and development budget. Page 36

National Academy of Engineering's Decade III campaign seeks to ensure U.S. scientific and technological leadership. Page 38

Science

From ACS meeting: dioxin data expanding but no consensus on health risk; pesticides from plants' natural defensive weapons; polymer-supported catalysts; polymer models for enzymes; chemical oscillators; LC retention mechanisms; large molecules and mass spectrometry; new synthesis routes in ceramics. Page 41

Technology

From Miami Beach: methods to remove bitterness in citrus products; amine purification using calcium bromide. Page 58



News Focus

Thirteen years after Stringfellow acid pits stopped receiving liquid toxic wastes, groundwater is still being fouled; Superfund revamping called for. Page 11

Chemical Plant Capacity Use Leveling Out

Use rate for basic chemicals at 77% in first quarter was about same as 1984's third quarter; polymers recovered, moving up to 80% from 76%

William J. Storck, C&EN New York
Bruce F. Greek, C&EN Houston

Chemical plant capacity utilization since the most recent recession has been a seesaw affair, rising and falling as chemical producers reopen shutdown plants to keep up with demand, which doesn't always take up all of the capacity that is reopened.

By the end of this year's first quarter, however, chemical producers seemed to have changed their capacity mix just enough to hold utilization rates at about the same levels overall as in third-quarter 1984. And demand has picked up enough to pull use rates up substantially from last year's first quarter.

According to C&EN's twice yearly survey of major chemical products, capacity use for basic chemicals averaged about 77% of nameplate capacity, compared with an average use rate of about 78% in the third quarter of 1984, but up from 72% in first-quarter 1984.

Average capacity utilization for the major downstream polymers, which had been down in third-quarter 1984 from the first quarter, regained almost all of the ground lost, averaging 80% of nameplate capacity in the first quarter this year, compared with 76% in the third quarter and 81% in the first quarter of 1984.

Capacity utilization is an important measure of the industry's health and is used as an indicator for the need for new production facilities and for increased capital spending. However, capacity utilization rates have risen much more slowly in the past couple of years than is normal for the chemical industry in times of economic expansion. Thus, plants have been delayed and capi-

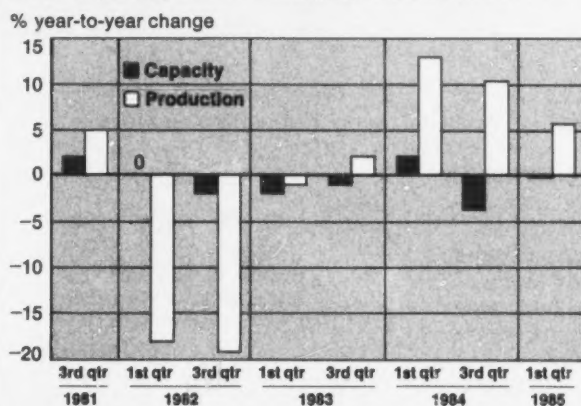
tal spending generally has been sluggish.

This may be changing, since in C&EN's annual survey of chemical company capital spending, firms indicated that monies going for new plant and equipment in 1985 would be up an average of 17% over 1984, which itself was up just 2% from the previous year (C&EN, Dec. 24, 1984, page 16).

However, it remains to be seen whether this rosy forecast of capital spending bears out in the long run. There still have been few new plant announcements by producers, especially by makers of the large-volume and still fairly depressed basic chemicals. Producers generally have been content to reopen older, less efficient plants and to increase production efficiencies in plants that already are running.

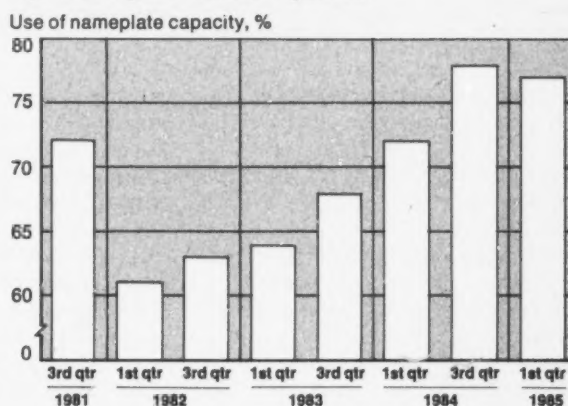
Then, too, production increases normally seen during postrecession years have just not shown up in the past couple of years. Those increases, which started off strongly just after the recession, have tapered off as

Basic chemicals production has risen and capacity has remained about level . . .



Sources: Industry and government data, C&EN estimates for 33 leading chemicals

. . . sending capacity use rates up from year-earlier quarter



Capacity utilization for basic chemicals has changed little since third-quarter 1984

Billions of lb unless otherwise noted ^a	First-quarter 1985			Third-quarter 1984			First-quarter 1984		
	Capacity (nameplate)	Capacity use (nameplate)	Effective	Capacity (nameplate)	Capacity use (nameplate)	Effective	Capacity (nameplate)	Capacity use (nameplate)	Effective
Petrochemicals—olefins and aromatics^b									
Ethylene	36.5	82%	92%	36.0	91%	100%	36.5	82%	91%
Propylene (chemical and polymer)	21.8	72	80	22.0	77	86	23.0	59	65
Butadiene ^c	3.9	61	68	4.5	58	64	4.5	51	56
Benzene (bg)	2.4	67	75	2.3	64	71	2.4	51	57
p-Xylene	5.7	85	100	5.2	86	100	4.9	85	100
Petrochemicals—C₁ derivatives									
Ammonia (mt)	18.5	91	95	17.5	89	93	17.8	88	91
Urea (mt) ^b	7.8	92	102	7.8	82	92	7.8	83	92
Methanol (bg)	1.9	58	65	1.7	74	83	1.9	60	67
Formaldehyde	8.5	64	67	9.2	61	65	9.2	56	59
Chlor-alkalies									
Chlorine (mt)	13.8	70	73	14.0	72	76	13.4	72	76
Caustic soda (mt)	14.6	70	73	14.9	72	76	14.3	68	72
Soda ash (mt)	11.0	72	76	11.0	74	78	11.0	77	81
Acids									
Sulfuric (mt) ^b	57.5	66	70	58.3	67	70	58.0	66	69
Phosphoric (P ₂ O ₅ , mt) ^{b,d}	12.7	81	85	12.5	87	91	12.5	82	86
Industrial gases									
Oxygen } (total, liquid ttd)	39.4	66	82	39.4	65	75	39.4	61	75
Nitrogen }									
Carbon dioxide (ttd) ^a	19.0	73	81	19.0	73	74	19.0	67	74
Mineral-based inorganics^b									
Sulfur (total, mmt)	18.0	52	—	17.0	55	—	17.0	31	—
Potash (mt)	1.6	135	—	2.2	90	—	2.2	55	—
Phosphorus	0.5	77	82	0.5	93	98	0.6	67	70
Plastics intermediates									
Styrene	8.5	80	94	8.2	95	110	7.8	92	108
Vinyl chloride	9.7	84	93	9.7	69	76	10.0	54	61
Toluene diisocyanate	0.6	122	136	0.7	84	93	0.7	102	113
Fiber intermediates									
DMT-PTA ^f	7.6	70	83	7.6	70	83	7.6	82	97
Ethylene oxide	7.0	87	97	7.0	86	95	7.4	84	93
Cyclohexane ^b	3.1	52	56	3.4	83	89	3.4	62	66
Adhesives, coatings intermediates									
Phenol	3.2	86	95	3.2	74	83	3.3	85	94
Vinyl acetate	2.4	69	73	2.4	99	105	2.4	87	92
Pigments									
Carbon black	3.3	81	90	3.3	87	96	3.3	86	96
Titanium dioxide	0.9	83	97	0.9	97	115	0.9	84	98
Solvents									
Acetone	2.8	64	71	2.8	59	66	2.8	67	75
Ethanol (mg)	210.0	81	90	210.0	88	98	240.0	78	91
Methylene chloride	0.8	65	72	0.8	65	72	0.8	69	77
AVERAGE		77%	84%		78%	86%		72%	82%

a bg = billions of gal, mt = millions of tons, ttd = thousands of tons per day, mmt = millions of metric tons, mg = millions of gal. b Substantial capacity currently shut down. c Total extraction capacity, which runs 25% more than basic production capacity. d Includes both wet process and furnace process capacity. e Excludes oilfield operations. f Dimethyl terephthalate and DMT equivalents of purified terephthalic acid. Sources: industry and government sources, C&EN estimates

U.S. companies have faced demand constrained by imports and increased competition from cheaper foreign products in overseas markets. This double whammy in foreign trade brought about by the strong U.S. dollar has kept chemical plant operating rates unusually low.

As a result, production has been

anything but healthy. According to U.S. government figures, output of basic chemicals in the first quarter on a seasonally adjusted basis was up 1.6% from the fourth quarter but was just 0.6% ahead of third-quarter 1984.

The other factor holding back chemical capital spending is pricing. With demand down, and thus

capacity utilization rates off, chemical producers have been finding it difficult to gain customer acceptance for price increases. Therefore, rates of return on chemical plants have been depressed, making new investment decisions difficult in the face of still high interest rates.

Myron T. Foveaux, deputy trade adviser, Office of the Chemical In-

Capacity utilization rates rise for polymers in first quarter

Billions of lb per year	First-quarter 1985			Third-quarter 1984			First-quarter 1984		
	Capacity (nameplate)	Capacity use Nameplate	Effective	Capacity (nameplate)	Capacity use Nameplate	Effective	Capacity (nameplate)	Capacity use Nameplate	Effective
PLASTICS									
Polyethylene, low density	10.1	84%	94%	10.3	79%	84%	10.1	83%	88%
Polyvinyl chloride	8.5	80	94	8.7	61	72	8.3	78	92
Polyethylene, high density	6.8	92	96	7.1	87	92	6.8	87	91
Polypropylene	5.6	88	97	5.4	91	101	5.3	90	100
Polystyrene	5.5	69	81	5.6	69	81	5.1	67	78
AVERAGE		82%	92%		78%	86%		81%	90%
SYNTHETIC FIBERS									
Filament yarn									
Polyester	1.5	83	89	1.5	74	79	1.5	84	90
Nylon	2.0	74	79	1.9	79	85	1.9	85	92
Olefin	1.2	81	85	1.1	62	65	1.1	63	67
Staple									
Polyester	2.8	71	76	2.8	78	83	2.8	82	87
Nylon	1.1	73	78	1.0	74	78	0.99	89	95
Acrylic	0.8	82	87	0.81	80	85	0.83	83	88
AVERAGE		77%	82%		74%	79%		81%	86%
OVERALL AVERAGE		80%	87%		76%	83%		81%	88%

Sources: Society of the Plastics Industry, Textile Economics Bureau, industry sources, C&EN estimates

dustry Trade Adviser, and assistant director of government relations for the Chemical Manufacturers Association, indicated to a meeting of the Synthetic Organic Chemical Manufacturers Association at Absecon, N.J., earlier this month that the price situation, especially for petrochemicals, is pretty gloomy. "Petrochemicals are being sold today at prices that recover just operating, but not fixed, costs," he said. "Operations are running at a cash-producing, but not reinvestment, level. There are few plans to build new capacity for most petrochemi-

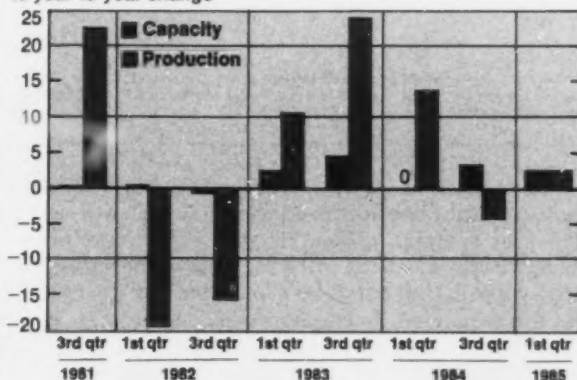
cals in the next few years. Existing plants are getting older and proceeding to obsolescence. There is little prospect that prices will improve enough to ensure U.S. investors a reinvestment rate of return on new plants."

This whole situation could change if the dollar weakens and interest rates drop. A weakening of the dollar could bring about some slight resurgence of export markets and could keep some foreign products out of the U.S., thus increasing demand for U.S. plants. And lowering of interest rates would mean

that cash for expansion could be borrowed at rates closer to the rate of return for the chemical plants involved. But, Foveaux warns, even a weakening of the dollar may not help much. Foreign producers in the past two years have set up distribution networks that they will be forced to protect against a lowering of the relative U.S. price. And, he says, in many cases, 10% of a market will set the price for a chemical product. Thus, according to Foveaux, U.S. chemical producers may still be forced, even with a drop in the relative value of the

Both capacity and production of polymers have increased ...

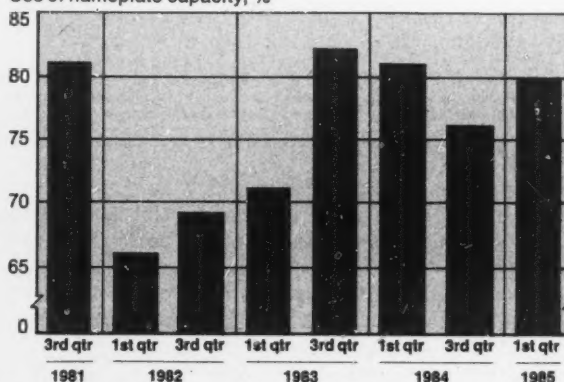
% year-to-year change



Sources: Society of the Plastics Industry, Textile Economics Bureau, industry sources, C&EN estimates

... resulting in a modest increase in capacity use rate

Use of nameplate capacity, %



C&EN capacity use indicator: the ground rules

Capacity use at chemical plants is difficult to measure and requires certain assumptions. These bring some order to the maze of variables affecting this critical indicator of the industry's health.

With the help of industry and government sources, C&EN measures capacity use as a percentage of both nameplate and effective maximums. Nameplate capacity is the official design capacity of plants. Effective capacity is the practical maximum after reductions for unplanned maintenance, corrosion problems, changes in product mix, and other influences. Although engineering companies and industry statistics groups try to make nameplate capacity data as real as possible, practical problems al-

most always reduce effective maximums to 85 to 95% of the official totals. For short periods, plants can run at more than 100% of effective top capacity, but such a rate doesn't last more than a few months.

Capacity use is given over as much of a calendar quarter as production data permit, with no seasonal adjustment. The figures are for plants actually operable. At present, some products such as ethylene, ethanol, chlorine, polystyrene, ammonia, and urea have plants temporarily shut down because of weak markets. These plants still are included in capacity totals. The totals exclude new plants just starting up and old plants out of operation for long periods because of accidents. As much as possi-

ble, capacity figures stay current with expansions.

Capacity data don't take into account other temporary fluctuations for fuel and electric power interruptions, equipment failure, and feedstock scarcity or substitution. The feedstock variables, for example, have been important in the past few years in ethylene production, altering maximum output for several coproducts such as propylene, butadiene, and benzene.

Products in C&EN's capacity use survey are the same as those in the Key Chemicals and Key Polymers series. These are the core products of the industry, the building blocks leading to downstream production of thousands of more specialized products.

dollar, to hold prices down to meet foreign competition.

A good example of the effects of foreign competition can be seen in synthetic fibers, use rates for which managed to eke out a rise to 77% of nameplate capacity in the first quarter, compared with 74% in last year's third quarter. But the rate is down from an average of 81% in the first quarter last year—this in spite of a resurgent housing market, increased discretionary spending by consumers, and plant closings within the industry. The main problem is not imports of fibers, but imports of finished and semifinished goods from abroad.

Only a few individual synthetic fibers increased in capacity use rates, contributing to the average increase in overall fibers capacity utilization in the first quarter of this year. For instance, polyester filament increased to 83% of nameplate capacity in the first quarter compared with 74% in the third quarter, and acrylic staple increased to 82% from 80%. More fibers, however, either dropped or maintained their depressed levels. Nylon filament fell to 74% in the first quarter from 79% in the third, and nylon staple slipped slightly to 73% from an already low 74%. Polyester staple dropped to 71% from 78%.

Thermoplastics faced largely the same situation of foreign competi-

tion of finished and semifinished goods, but producers managed to overcome some of the problems to raise capacity utilization to an average of 82% from 78% in the third quarter and 81% in the first quarter last year. Showing the most improvement in this year's first quarter was polyvinyl chloride, whose utilization rate climbed to 80% from a much depressed 61% in the third quarter of 1984. In the first quarter of last year, the use rate for PVC was 78%.

For the remaining thermoplastics, there was little change in utilization rates. Capacity use for low-density polyethylene increased to 84% from 79%; high-density polyethylene rose to 92% from 87%; polypropylene dropped to 88% from 91% as some new capacity came on stream; and polystyrene stayed at 69%, even with a slight decline in capacity.

Increases in capacity utilization in the downstream products are hardly reflected in the basic chemicals, however. For these, plant capacity use rates declined a slight amount to an average of 77% from 78% in the third quarter of 1984, but are up some from 72% in first-quarter 1984.

For the first quarter this year, both the 20 organic products and the 13 inorganic chemicals surveyed showed average capacity use rates

of 77%, compared with 78% for both in the third quarter. In the first quarter last year, however, capacity utilization for the organics averaged 74% and that for the inorganics averaged 68%.

The chief reason for the rapid rise for the inorganics last year and the subsequent leveling off this year was the ending of the government's payment-in-kind (PIK) crop set-aside program, which cut into fertilizer demand drastically. This has pulled fertilizer chemicals up substantially, raising the average for all the inorganics.

The end of the PIK program gave a shot in the arm to fertilizers specifically, and inorganics generally, but in the near term there are probably no more single events that will have the major effect that the termination of this program did. Thus, chemical producers must resign themselves to slow growth in capacity use for some time. Last week's lowering of interest rates may well help pull down the value of the dollar somewhat and thus help exports, but this is a long-term solution.

With the economic expansion proceeding only slowly, there is little hope for many, especially basic, chemical products to get back to historic operating rates in the 80 to 90% range—the range that will justify new plant expansions. □

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CHEMICAL & ENGINEERING

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Plastics
New grades contribute
to expanding market

Page 23

News of the Week

■ Chemical stocks were in the vanguard of a market advance that seems to be holding. Page 6

■ Physicists tout the superconducting supercollider but the price tag is estimated to be \$4 billion. Page 7

■ Costs to industry of disposing of hazardous wastes may almost double by 1990. Page 7

■ Under President's tax reform proposal definition of qualifying research is tightened, award winners pay taxes on cash prizes. Page 8

■ Dow Chemical will buy Minneapolis-based membranes maker FilmTec. Page 8

Cover: Union Carbide/Shell joint-venture polypropylene plant in Seadrift, Tex.

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Business

Although the strength of the U.S. dollar hurt drug firms' first-quarter results, profitability increased. Page 12

U.S. petrochemicals may have a future after all, company vice president points out, even with Saudis in the picture. Page 14

Government

Superfund director William Hedeman discusses his cleanup strategy for the country's most hazardous waste dump sites. Page 17

Great Plains Coal Gasification plant will shut down shortly if the government fails to give it additional funds. Page 19

Science

Japanese chemists identify various mechanisms of stabilization and color variation of anthocyanin pigments in flowers. Page 51

Education

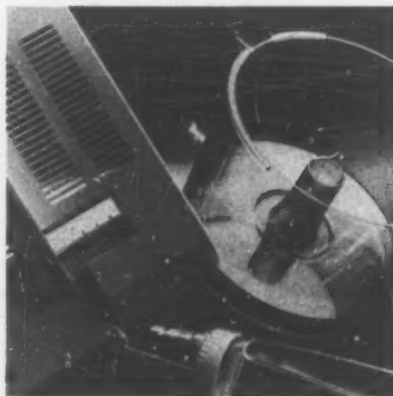
Amoco Foundation will provide \$667,000 to train 120 Chicago public school teachers in science and mathematics. Page 52

Technology

K-20 may be a winner—water sealant, insecticide, and possible encapsulator, detoxifier of chlorinated hydrocarbons. Page 52

ACS News

The society honors its 50-year members; each receives a special pin, certificate, and free registration at ACS meetings. Page 56



Product Report

Increased development work is expanding plastics' use in existing markets, opening up new applications. Page 23

Physicists promote new accelerator

High-energy particle physicists are trying to sell other scientists, politicians, and the public on their latest dream machine. It's called the superconducting supercollider (SSC). If the machine is built, upon completion in the mid-1990s it will cost about \$4 billion in 1985 dollars.

Even particle physicists, who are well acquainted with big-budget projects, realize that a \$4 billion price tag sounds steep in an era of tight budgets. At last week's annual meeting of the American Association for the Advancement of Science in Los Angeles, those physicists convened a symposium to push the necessity of SSC as "a new window on the universe."

The proposed accelerator would be a synchrotron with a circumference of 90 to 160 km. It would accelerate two beams of protons in opposite directions to energies of 20 trillion electron volts (TeV). By contrast, the Tevatron at Fermi National Accelerator Laboratory, now the most powerful U.S. synchrotron, has a 6-km circumference and attains beam energies approaching 1 TeV.

SSC gets its moniker from use of electromagnets based on superconducting materials to guide the beams of protons around the circular track of the synchrotron. According to physicists involved in the project, the suitability of superconductivity for synchrotrons has been demonstrated in successful operation of the Tevatron.

At a AAAS press conference, Fermilab physicist Leon M. Lederman argued that SSC "is not just another accelerator." SSC is driven by a set of related "scientific crises," he says, which center on the fundamental nature of mass. The energy range set for SSC is not an arbitrary step to higher energies, but has been determined on the basis of theoretical calculations showing that 40-TeV collisions will approach conditions that existed in the first instants after the Big Bang, he says. As such, studies of such collisions would provide experimental data on open questions in current grand unification theories.

Lederman puts forth a familiar, heady line of reasoning to justify SSC's expense. The device, he says, is yet another "critical" stage in physicists' efforts to define a "complete world view," an effort that dates back intellectually 2500 years. During that time, he says, a clear thread links the evolution of particle physics and the various scientific revolutions that have changed humans' view of the universe and created modern civilization.

Lederman stresses, however, that SSC isn't likely to be the final step in physicists' quest for ever more

powerful accelerators. The history of particle physics shows that each new energy domain that has been achieved has opened up a new set of questions, he says.

Preliminary design work for SSC already is being done at Lawrence Berkeley Laboratory. R&D for the project is under way at several national labs, universities, and industrial firms. And, as has happened with several recent big-budget scientific projects, many states, including California, Texas, Illinois, and North Carolina, are scrambling to be selected as the SSC site. □

Costs of industrial waste management to rise

A Congressional Budget Office analysis of the costs of handling hazardous waste and cleanup of waste disposal sites finds that by 1990 industry could be paying nearly twice as much for handling wastes as it paid in 1983.

Prepared at the request of the Senate Committee on Environment & Public Works, the study analyzes these costs and several proposed ways of collecting money for Superfund, as well as technologies available for reducing the volume of hazardous wastes. CBO examined the effect of 1984 changes in the Resource Conservation & Recovery Act and of an expanded Superfund program on what various industries will have to pay to dispose of hazardous wastes.

CBO estimates private industry spent a maximum of \$5.8 billion for disposal and treatment of hazardous wastes in 1983, and state and federal governments spent about \$700 million. Changes in the law, including lowering the exemption for low volumes of waste from 1 metric ton per month to 0.1 metric ton per month, and a larger Superfund, could raise that total for industry to \$11.2 billion by 1990, an increase of nearly 94%, according to CBO. The chemical industry would be expected to pay \$3.1 billion, or 28% of that total.

In evaluating the various options for waste control and for raising revenues for Superfund, CBO makes no recommendations, although it gives more weight to some ideas

Cost of complying with waste disposal law could double by 1990 unless waste volume is cut

1 Billion	1983	1990	
		No waste reduction	Waste reduction
Chemicals and allied products	\$1544	\$ 3,122	\$2283
Primary metals	1243	2,302	1681
Fabricated metal products	809	1,191	735
Rubber and plastic products	796	2,026	1771
Miscellaneous manufacturing	267	356	308
Non-electrical machinery	254	324	279
Motor freight transportation	229	247	247
Transportation equipment	191	360	296
Electrical and electronic machinery	156	237	163
Petroleum and coal products	136	940	634
Wood preserving	56	91	61
Drum repair/liners	6	6	2
TOTAL	\$9779	\$11,201	\$3499

Source: Congressional Budget Office

than others. Waste reduction by industry is the most practical way to save, CBO indicates. Without waste reduction, some industries, such as the wood preservative industry, will have waste control costs that exceed their projected profits in the next five years. Effective waste reduction could halve the increase in waste control costs. It also would reduce the need for landfills.

One thing the government might do to help is to fund more R&D on advanced waste and hazard reduction measures. EPA is not now supporting such research. Better enforcement efforts, including more inspections, would encourage compliance with the laws. And some sort of refund or deposit system might be set up to encourage recycling of some wastes, such as solvents and waste oils.

The best revenue bet is a waste-end tax, CBO says. "Waste-end taxes would go far to encourage lower hazardous waste production and to support waste management shifts intended by the 1984 RCRA amendments," the report concludes. The broader tax base of the waste-end tax is seen as a big advantage over reliance on feedstock taxes (Superfund's method). Other analysts have said waste-end taxes are impossible to administer, but CBO appears to believe their benefits overshadow this problem. The report does acknowledge that as wastes diminish, so will revenues from this tax. The shortfall then might have to be made up by corporate receipt taxes or general tax revenues. □

Tax reform would renew R&D tax credit

In President Reagan's speech to the U.S. public last Tuesday night, he mentioned the need "to strengthen growth by preserving incentives for investment, research, and development." And among all the business tax incentives that are repealed or curtailed in the most recent Administration tax plan, the credit for R&D expenditures, which expires this year, is somewhat exceptional in that it would be renewed at least until Dec. 31, 1988.

However, as detailed in the Treasury Department's 460-page explanation of the tax proposal, the definition of qualifying research would be tightened. The department notes that some taxpayers take the view that the costs of any trial-and-error procedure are eligible for the current R&D credit, even though there may be little doubt about the outcome of the procedure. Under its new proposal, research would qualify for the credit only if it relates to a process of experimentation encompassing the evaluation of alternatives that involve a serious degree of uncertainty about whether the desired results can be achieved.

The Administration's proposal does not directly address the question of allowing a credit for industry contributions to fund basic university research or an enhanced charitable deduction for contributions of scientific equipment to universities. Treasury says, however, that contributions "would be considered in the context of legislative efforts to extend the research credit."

But if the scientists who do the research happen to win monetary awards for their work—such as the American Chemical Society's Cope Award or even a Nobel Prize—they would have to pay taxes on such awards. Under current law, prizes or awards made primarily in recognition of scientific achievement are not taxable. The Administration's new tax plan would repeal that provision of the tax law as well as the current exclusion allowed for scholarships and fellowships. Under the new plan, degree candidates would have to include scholarships and fellowships in their gross income, unless they were required to be, and were, spent on tuition or equipment needed for courses.

It's still uncertain whether these provisions will be included in the final tax bill that emerges from Congress, if one does. The opposition forces are already gathering. Groups as diverse as the American Petroleum Institute, the International Chemical Workers Union, and the Solar Energy Industries Association are registering their opposition to various portions of the Administration's tax proposal. □

Dow will acquire membranes producer

Going outside the company to expand its young membranes business, Dow Chemical has signed a definitive agreement to buy FilmTec Corp., a Minneapolis-based manufacturer of reverse-osmosis membranes, for about \$75 million.

After the merger, FilmTec, which owns three facilities in the U.S. and one in the U.K., will become a wholly owned subsidiary of Dow and will operate as a freestanding organization within Dow's membrane products department. In the 12 months ending March 31, 1985, FilmTec, whose products are used in water purification and other separation applications, reported net income of \$1.4 million on sales of \$11.1 million.

The acquisition will broaden the range of Dow's membrane products department, which came into being last September in the combination of Dow's Midland-based hollow fiber membrane venture and Cynara Co., a Houston provider of gas separation services to the oil and gas industry. Cynara is a 90%-owned subsidiary of Dow. Since then, the department has had one major new product introduction: Generon air-separation systems for low oxygen-content nitrogen used in the chemical, metal producing, metalworking, and food processing industries (C&EN, March 4, page 26).

Once the merger with FilmTec is completed, Dow intends to transfer some of its reverse osmosis membrane commercial activities to FilmTec. Few changes are expected in FilmTec's staff.

Dow will pay FilmTec shareholders \$21.75 in cash for each of the 3.45 million shares outstanding. The merger agreement, which has been approved by the boards of directors of both companies, must still be agreed to by FilmTec shareholders, but Dow already has arranged for the guaranteed right to vote and purchase an aggregate of 30.4% of FilmTec's common stock now held by eight owners. In addition, Dow has an option to buy up to 1.6 million newly issued shares for \$21.75 each. □

Drug Firm Profitability Increased in First Quarter

Cost controls and adjustments to competition in hospital supply market give profit margins boost despite small increase in sales revenues

David Webber, C&EN New York

The strength of the dollar against foreign currencies continues to shave revenue gains for the pharmaceutical industry. Although this factor has not been enough to halt growth, it has slowed it considerably. For the second quarter in a row, consolidated sales of a group of 18 major drug companies increased in first-quarter 1985 only 3% over the year-earlier period. The rate of growth has been declining steadily since fourth-quarter 1983, when sales rose 8% over those of fourth-quarter 1982.

However, by pruning expenses and adjusting their product lines to deal with new competitive pressures in the hospital supply market, drug

firms nevertheless have succeeded in raising profitability for the third straight quarter. At 11.8%, the consolidated profit margin (after-tax income as a per cent of sales) of the group of 18 companies was well above the first-quarter 1984 level of 11.2% and the postrecession low of 10.9% in the second quarter of last year.

Although growth in net income for the group, at 9%, was below the year-earlier level of 12%, almost all of the 18 companies managed to boost earnings in the first quarter. Only Avon Products, with a 23% decline, and Upjohn, which had a 21% decline in earnings, reported lower net income. By contrast, five of the 18 firms showed declines or no growth in sales during the quarter.

As has become common, earnings statements bemoaned the impact of the dollar's strength. Becton, Dickinson, for example, which reported a meager 1% increase in sales, notes that if exchange rates had remained unchanged from their first-quarter 1984 levels, revenues would have

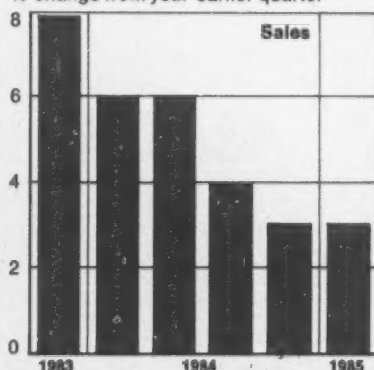


Horan: dollar's strength hurt results

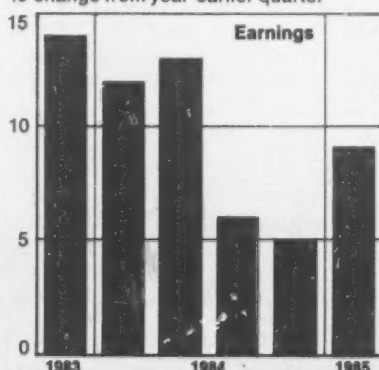
increased more than 4%, or \$8 million, and that earnings would have been \$800,000 higher. In local currencies, the company says, sales outside the U.S. rose 14%, but currency translation cut that to 3% growth to \$71.7 million, or 25% of total sales. Sales in the U.S., at \$216 million,

Pharmaceutical industry 1985 first-quarter results

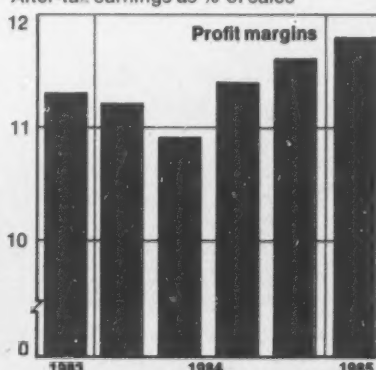
% change from year-earlier quarter



% change from year-earlier quarter



After-tax earnings as % of sales



Note: All sales, earnings, and profit-margin statistics are based on combined results of the 18 companies listed on page 13.

were unchanged from the year-earlier quarter.

Similarly, Bristol-Myers, which reported an overall 3% sales gain, saw 5% growth in domestic sales offset by a decline in international sales because of the adverse effect of exchange rates, says Richard L. Gelb, chairman of the company. In local currencies, overseas sales increased, he says. Exchange rate fluctuations cut total company sales growth about 4%, or \$41 million, in first-quarter 1985.

Other companies give similar reports. "First-quarter results were adversely impacted by the continued strength of the U.S. dollar," says John J. Horan, chairman and chief executive officer of Merck & Co. "If the effects of currency exchange were excluded, sales would show an increase of 8%." Likewise, Edmund T. Pratt Jr., chairman and chief executive officer of Pfizer, points out that strong performance by the domestic health care business was offset by a decline in overseas results due to the strong dollar. And Robert P. Luciano, chairman, president, and chief executive officer of Schering-Plough, which reported no increase in sales in the first quarter, says revenues would have climbed 8% were it not for currency exchange factors.

Performance by the drug companies' chemical business segments was mixed. Eli Lilly, for instance, whose increase in pharmaceutical sales was the chief bright spot in a 2% rise in overall revenues, says the primary drag on sales dollars was the agricultural chemicals business. Lower selling prices for the firm's Treflan herbicide brought the total down, overwhelming what the company describes as excellent sales growth by Sonalan herbicide, now in its second marketing year. Sales of animal health products also declined in the first quarter.

For Avon, on the other hand, whose primary business of beauty products did poorly, the Mallinckrodt division reported a 7% increase in sales. And Upjohn, which suffered through a 3% decline in overall sales, says its chemical segment's sales climbed 10% in the first quarter, mostly because of increased worldwide polymer sales and im-

Drug earnings rose 9% in the first quarter

	Sales		Earnings ^a		Change from 1984		Profit margin ^b	
	(\$ millions)				Sales	Earnings	1985	1984
Abbott Laboratories	\$ 756.2	\$102.2	5%	17%	13.5%	12.2%		
American Home Products	1207.5	180.9	6	10	15.0	14.5		
Avon Products	669.4	23.1	-8	-23	3.5	4.1		
Baxter Travenol	486.0	39.7	21	12	8.2	8.8		
Becton, Dickinson	287.4	22.0	1	62	7.7	4.8		
Bristol-Myers	1082.5	124.6	3	13	11.5	10.4		
Lilly	908.8	160.9	2	10	17.7	16.4		
Merck	856.3	131.5	1	5	15.4	14.7		
Pfizer	945.7	147.3	3	15	15.6	13.9		
Revlon	551.2	28.1	-2	15	5.1	4.3		
A. H. Robins	166.4	21.5	6	35	12.9	10.2		
Schering-Plough	487.0	54.1	0	2	11.1	11.0		
G. D. Searle	337.1	34.9	20	38	10.4	9.0		
SmithKline Beckman	770.0	131.8	7	1	17.1	18.2		
Squibb	453.1	42.3	6	15	9.3	8.6		
Sterling Drug	415.7	31.9	-6	3	7.7	7.0		
Upjohn	545.5	51.6	-3	-21	9.5	11.5		
Warner-Lambert	794.6	59.9	2	10	7.5	7.0		

a Excludes significant extraordinary and nonrecurring items. b After-tax earnings as a percentage of sales.

proved polyurethane foam sales. Still, because of high costs in foreign markets and the strength of the dollar, Upjohn's chemical segment recorded an operating loss.

Merck chairman Horan says that company's specialty chemical and environmental products sales declined from their year-earlier levels because of competition and currency fluctuations. For Pfizer, the dollar's strength and "less robust market conditions" led to flat sales in specialty chemicals and sales declines of 2% in agriculture and 5% in materials science, the company says. And Sterling Drug's first-quarter sales in the chemicals and other products business segment, at \$34 million, were down 7% from a year earlier.

Some companies blame part of the mediocrity of their performance for the quarter on the costs of restructuring and similar programs that, although crimping results now, will yield higher earnings in the future. Avon, for instance, notes that its beauty products operation, which had a 14% decline in sales, completed a restructuring effort in the first quarter. Also, Upjohn points out that changes made in marketing strategy for its agricultural business was the primary cause for a 7% decline in sales for the segment. The company says that the change

in its seed marketing approach deferred revenues until the second quarter. In addition, Upjohn divested its plant health business in the first quarter, further lowering revenues.

G. D. Searle, having hitched its wagon for now to its star Nutra-Sweet brand aspartame sweetener, continued its robust growth. Sales rose 20% and net income 38% in the first quarter, with \$176 million, or 52% of all sales, coming from aspartame. At the same time, aspartame margins declined, the result of price adjustments ceded to soft drink manufacturers to hasten their shift to the 100% aspartame sweetener content in diet drinks that now prevails over the earlier aspartame-saccharin mix.

In addition, Searle, which is striving to pump up its aging pharmaceutical product line, spent 16% more on R&D in the first quarter than a year earlier. Also, earnings were reduced by expenses related to the company's exploration of possible methods by which the holdings of the Searle family might be diversified. That episode, which included talks with several other companies interested in buying either the entire corporation or parts of it, ended in late March, when Searle decided to continue as an intact, independent operation. □

U.S. petrochemical outlook not so dismal

Despite the new low-cost competition from Saudi Arabia and other energy-rich nations, the future of the U.S. petrochemical industry is not so bleak as some forecasters have painted it.

The three traditional petrochemical-producing areas—the U.S., Japan, and Western Europe—are about set to absorb the exports of ethylene derivatives from the first round of plant building in the new petrochemical-producing areas such as Saudi Arabia and Canada. A second round of expansion is not yet in sight for the new areas. That means that the traditional producing areas, including the U.S., can look forward to resuming good growth in the late 1980s.

That, at least, is how Richard D. Dodge sees the U.S. petrochemical outlook. Dodge, vice president of DeWitt & Co., Houston, told a recent meeting of the Chemical Marketing Research Association in New York City that sometime in the early 1990s, U.S. ethylene producers will have to start thinking about new capacity. Exactly when depends upon the timing and volume of imports from the new producers of ethylene and its derivatives. Meanwhile, as world ethylene output leans more toward light feedstocks, propylene will become tight in the U.S. and throughout the world. The U.S., Dodge says, probably will become the major propylene supplier to the rest of the world.

Dodge acknowledges that a major shift in international ethylene

supply, if not demand, is under way. Countries with low-cost energy resources are converting those resources to ethylene and its derivatives. With little demand at home, the logical alternative for those countries is the export market. The best-known example is Saudi Arabia, but it is also true of Canada, Singapore, and, to a lesser extent, several other countries.

U.S. producers can't match the production costs of these newcomers. Dodge estimates that it costs, on average, \$420 to make a metric ton of ethylene in the U.S. In Canada, the comparable cost is only \$340, and in Saudi Arabia a meager \$210 (10 cents per lb).

Dodge says that in the four-year period 1984-87 the traditional producing areas will have to absorb 3 million to 3.5 million metric tons (ethylene equivalent) of product from the new producers. Half of that will move into the U.S. Japan and Western Europe will split the remainder almost evenly.

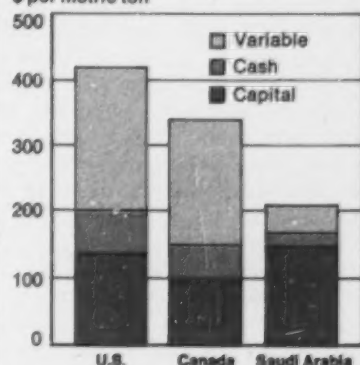
However, by 1988, the U.S. market will absorb the impact of these imports and growth can resume once more, Dodge says. New capacity could be needed in the U.S. by 1990 or 1991, although imports could push the date ahead to 1992 or 1993. The alternative, he says, could be even more imports of ethylene derivatives, if an economic supply is available from somewhere in the world. Whether there will be more capacity or more imports for the U.S. is the subject of a heated debate, Dodge says.

Right now, no plans have been announced for a second round of new ethylene complexes. But that very well could change by the early 1990s, Dodge says, primarily in southern and eastern Asia. Several countries in the area have the necessary resources, which they have tried to convert into petrochemicals over the past few years. In the next decade, they may finish the job and eliminate the need for imports of some ethylene derivatives.

Dodge doesn't believe that the potential Asian producers will become major exporters, like Saudi Arabia and Canada. Instead, they will use their production to reduce imports, develop their own econo-

Ethylene products' costs are highest in U.S.

\$ per metric ton



Source: DeWitt & Co.

mies, and convert their petrochemicals into downstream products using low-cost labor. It is those finished goods that will be exported, he explains. Dodge also expects other developing countries to try satisfying their own internal demand and to provide some additional product for export, such as Brazil now does.

The world ethylene feedstock picture will change, too. Dodge expects a definite shift to take place to ethane-based feedstock. About 22% of the world's ethylene was produced from ethane last year. By 1994, that share will increase to 30%. That means that the shortfall of coproducts from ethylene plants, particularly propylene, will have to come from other sources.

In the U.S., ethylene production will shift from light feedstocks to heavier feeds, such as naphtha and gas oil. And that could help U.S. producers meet the expected propylene shortage throughout the world.

Historically, most propylene has come from refineries, primarily from catalytic crackers. The U.S. has more catalytic cracking capacity by far than any other country. Thus, says Dodge, as world propylene supplies decline, the U.S. will become the most likely source of new supplies. He sees opportunities for propylene derivatives plants on the West Coast because demand for exports to the Far East will be great.

Earl Anderson, New York

World will shift to lighter feedstock

Feedstock	World ethylene production, %		
	1984	1989	1994
Ethane	22%	27%	30%
LPG	15	14	11
Naphtha	54	48	46
Gas oil	8	10	12
Other	1	1	1
TOTAL	100%	100%	100%
Production (billion of lb)	84.2	100.4	114.5

Source: DeWitt & Co.

Plastics Expand Into New Markets

Bruce F. Greek, C&EN Houston

Plastics, in spite of the lingering hype from the 1960s, are characterized in some quarters as stodgy downstream chemical products. Indeed, the domination of the plastics industry by the large-volume commodity products does indicate a mature segment of the economy.

Looking beneath the commodity end of the business, however, a lot of development work is under way that's lending an air of excitement to plastics and changing some of their applications. Much of that work is allowing them to expand into markets that heretofore have been served only by more traditional products such as glass and metals.

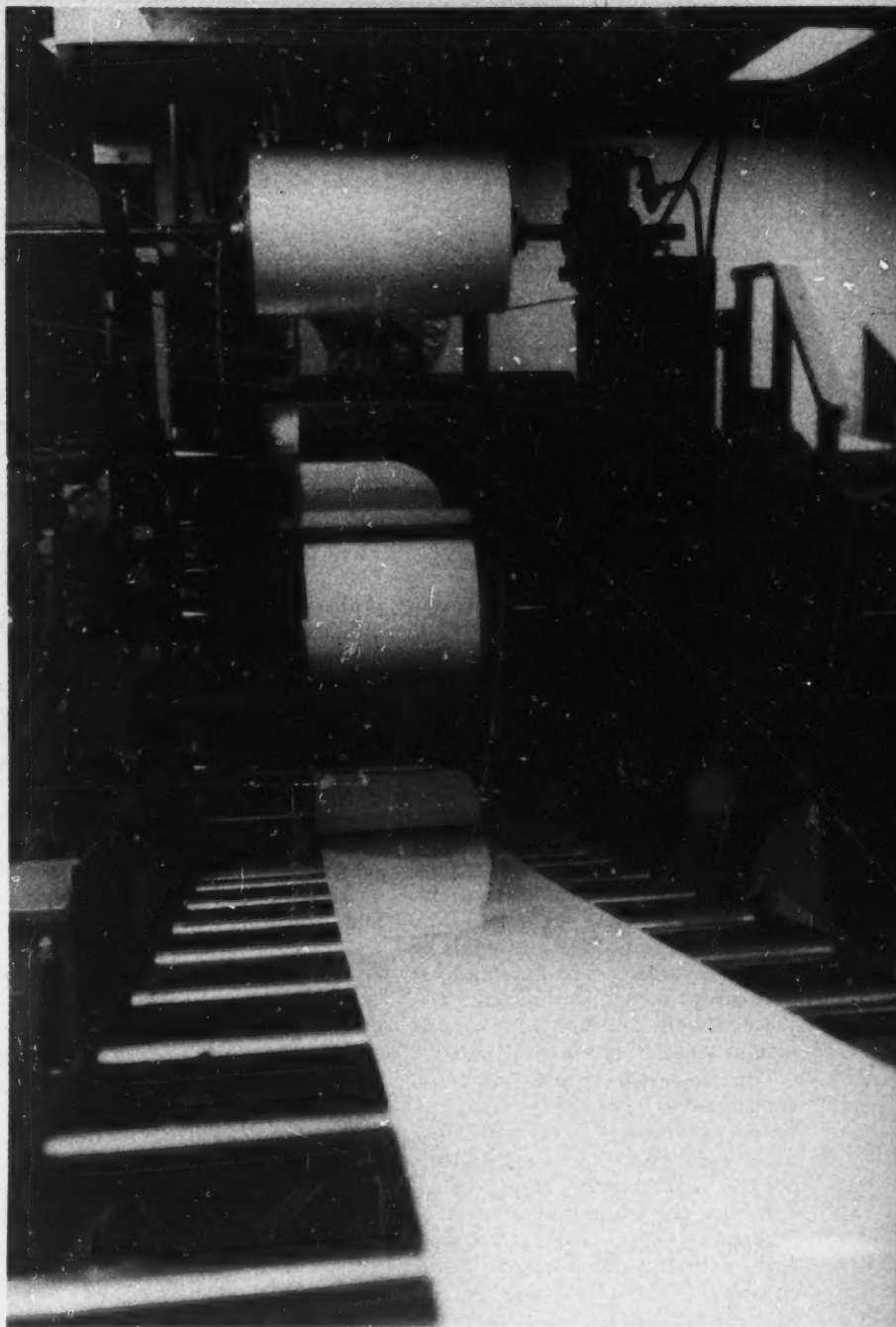
Pushed by these and established uses, the plastics industry again will post new highs this year in all the usual statistics of production, consumption, and value of shipments. However, growth in these areas of performance could be somewhat lower than in 1984 when recovery

from the most severe recession in 50 years was completed. Still it quells much talk about a maturing plastics industry.

Production in the U.S. of all kinds of plastics, excluding polyurethanes, likely will exceed 46 billion lb in 1985, up some 4% from 1984—and some marketers are forecasting a 7% jump.

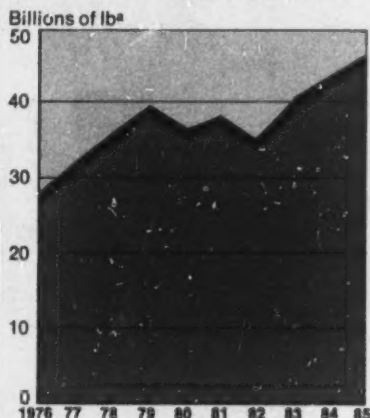
U.S. consumption of plastics is expected to grow even faster. At

the same time, exports are declining and imports are making new inroads. Exports of all kinds of plastics in the early 1980s exceeded 10% of production. Last year, under pressure from new plastics plants built in many developed and developing countries, exports slipped to about 9% of output. The volume of plastics imported into the U.S. also is expected to grow slightly, adding to the amount that will be consumed here.



Extrusion of Calibre polycarbonate resin at Dow Chemical's Freeport, Tex., plant

Plastics production moves toward 50 billion lb record



^a Excluding polyurethanes. Sources: SPI Committee on Resin Statistics, C&EN estimates

The total value of plastics shipments, including exports, might go over \$20 billion for the first time. Among chemical products, plastics rank third in value of shipments, exceeded only by industrial organic chemicals and drugs, according to Department of Commerce data. Among other commodities, at the 1985 forecast value for shipments, plastics will rank fourth in value of shipments after steel, paper and paperboard, and aluminum, and displace cement and concrete, which formerly had held fourth place.

Growth of the various polymers considered to be plastics varies widely. Because their base is small, some new, small-volume, high-priced polymers are growing at high rates. However, the large-volume thermoplastic polymers—such as polyolefins, polystyrene, and polyvinyl chloride (PVC)—and most of the long-established thermoset polymers that together account for more than 80% of total plastics production will have growth rates in the single-digit range.

The plastics industry is huge, comprising all major-sized chemical companies, hundreds of small chemical companies, and many chemical subsidiaries of oil, steel, and diversified companies. Some of these companies produce the monomers that they subsequently polymerize to other products. Some also produce the various additives and other materials used in processing plas-

tics either for themselves or for sale to others.

Among major plastics producers who are integrated back to monomers, some—mostly those who are a part of oil companies—are integrated further back to hydrocarbon raw materials. Among such polyolefin producers are Amoco Chemical, Exxon Chemical, Gulf Oil Chemicals, Mobil Chemical, Phillips Chemical, and Shell Chemical, that either produce ethylene and propylene or obtain these olefins from their parent oil companies. These companies account for about 40% of the ethylene capacity in the U.S. Their combined polyethylene capacity also accounts for about a third of the total of low-density and high-density polyethylene capacity.

Companies that polymerize monomers that are one chemical step beyond the basic olefins are more likely to buy olefins and other monomers, such as benzene and chlorine for styrene and vinyl chloride. Dow Chemical is an exception in that it makes vinyl chloride and sells this monomer but does not make polyvinyl chloride. Dow does make styrene and polystyrene, as well as other vinyl polymers.

The vinyl plastics are produced more often for captive consumption by companies that may buy monomers. Some of these companies make polymers for specific markets, such as Certain-Teed Products for flooring materials; Formosa Plastics, B.

F. Goodrich Chemical, and Shintech for pipe and fittings; and Air Products & Chemicals, Du Pont, and Monsanto for coatings.

The thermoset plastics—phenolics, polyesters, epoxies, and urea/melamines—require more than one reaction step beyond the initial material. Many of these plastics involve several steps before a polymer of commercial interest is made. Thermosets producers offer both very specialized and commodity polymers.

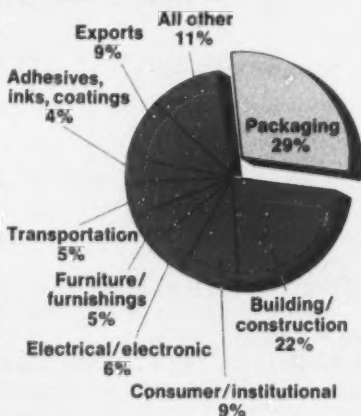
Some of these producers have large captive uses for their production. For example, Georgia-Pacific, Masonite, and Owens-Corning Fiberglas make phenolic resins for adhesives and binders in building materials that they also make. Formica makes melamine resins for its line of surface coverings. Others, such as American Cyanamid, Borden Chemical, Chembond, Monsanto, and Reichhold Chemicals, make urea and melamine resins for adhesives of various kinds that they market or sell to others that formulate and sell adhesives.

Epoxy and polyester resins are a little different. Most epoxy resins made by such companies as Celanese, Ciba-Geigy, Dow, Reichhold, and Shell Chemical are sold to other companies that in effect fabricate the resins into end products, including coatings, adhesives, and specialties. In much the same way, many unsaturated polyester resins that are made, for example, by ICI Americas, Koppers, Silmar division of Sohio Chemical, and Union Carbide go to others for preparation of end products.

With producers making a wide range of both commodity plastics for many kinds of uses and specialty plastics for very specific uses, the end uses of plastics have grown to encompass all segments of consumer products. Without plastics, present life styles would revert to levels of 150 years ago. Many different plastics fit the same uses and some fit only a single use. The interpolymer competition continues to grow in most end uses, leading to constant development work on new polymers, blends, composites, and the like.

The major-volume plastics—the

Packaging dominates plastics' markets



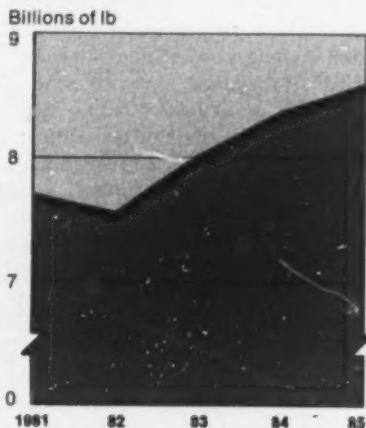
Source: SPI Committee on Resin Statistics Annual Markets Survey

Special grades characterize low-density polyethylene

Even after a few years of commercial availability, linear low-density polyethylene (LLDPE) keeps getting lots of attention, much of it generated by ongoing development work. At the same time, conventional low-density polyethylene keeps moving along with remaining plant capacities operating at high levels.

Capacity to make all forms of LDPE (densities of 0.94 or below) totals about 10 billion lb a year. That's a soft estimate, however, because of shifting between high-density and low-density product in plants that have been converted to make LLDPE or in new plants

Production



Sources: SPI Committee on Resin Statistics, C&EN estimates

built specifically for LLDPE. About a quarter of the total of LDPE capacity can be operated to make LLDPE. Unreported conversions could later raise this fraction even higher. Some HDPE capacity also can be used to make LLDPE.

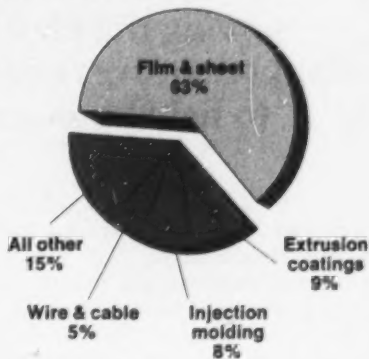
If production of all forms of LDPE reaches 8.6 billion lb this year, then the average plant operating rate will be about 85% of nameplate capacity. That volume would mean another good year for LDPE.

Another factor that could make this a strong year for polyethylene manufacture is the continuing pressure on ethylene prices, although to an integrated producer, this pressure isn't necessarily a good thing. But lower raw material costs could help to offset the pressure on polymer prices from consumers who follow the material cost situation closely.

High production, however, doesn't always make for high profitability, and in the past this caveat fitted the polyethylene business. To overcome the severe competition, producers have been coming up with ever more specialized grades of polyethylene to fit the special needs of fabricators. To a degree, these developments have helped production because initial demands for large-scale evaluations make some additional inventory necessary.

These many specialized grades, numbered in the hundreds by some in the industry, also add to producers' costs. Operators lose time by shifting

Consumption



Source: C&EN estimates

between molecular weights or between different polymer properties. Some operators, however, claim that time lost is minimal because of the flexibility they have built into their plants. Nevertheless, additional testing and other costs, including additives for special purposes, do boost the total production cost. Producers may not be able to recoup the higher cost for very long by higher price because competition soon offers an identical or similar resin.

Specialty resins will continue to be brought to market. One example receiving evaluation by fabricators is the very-low-density polyethylene resins commercialized by Union Carbide last fall. Those resins have densities as low as 0.900 and are claimed to have unusual softness, making them competitors for some of the ethylene copolymer resins.

workhorses of the industry—are the polyolefins, polystyrenes and other styrenic polymers, polyvinyl chloride, epoxies, phenolics, and unsaturated polyesters. Among the many other classes of plastics, some, such as polyurethanes, are produced in very large volumes, and others, such as polycarbonates, in small amounts. Some of these plastics are grouped together because of the kinds of uses they have—for instance, engineering plastics.

Nylon resins are considered to be engineering resins, but because of their recent rapid growth, they have attained a category of their own. Production last year of nylon resins used for other than textile applications was nearly 400 million lb, up

substantially from 321 million lb in 1983, according to the Society of the Plastics Industry's Committee on Resin Statistics. About two thirds of nylon plastics are used as injection-molded parts, such as gears and bushings for automotive, appliance, toy, photographic, and other applications. Other substantial uses include films, electronic parts, wire and cable coverings, and in large monofilaments used as fishing lines and in making rope.

Other engineering thermoplastic resins include the acetals, polycarbonates, polyphenylene sulfides, thermoplastic polyesters, polyphenylene oxides, polyimides, polyamide-imides, and fluoropolymers. Details of individual production for

most of these plastics are not available.

Many of the major plastics companies make one or more of these thermoplastic engineering resins. This group of resins has moved up and down the production scale, depending on the economy and on application developments. In 1983, production of engineering resins topped 1979 production and then increased to about 800 million lb in 1984.

Because of the wide diversity in uses of these resins, classifying end uses is difficult. Electrical and electronic components account for about 35% of the estimated total. Transportation components take another 15%, with construction, consumer

High-density polyethylene capacity use is high

High plant operating rates continue to characterize high-density polyethylene (densities above 0.94) production. The introduction of linear low-density polyethylene at one time posed a threat to the rapidly growing demand for HDPE, but as yet, this threat hasn't become significant enough to reduce HDPE consumption.

Some slowing in production growth of HDPE is expected during 1985, just as a slower growth is forecast for almost all major-volume polymers. This forecast is based on an expected

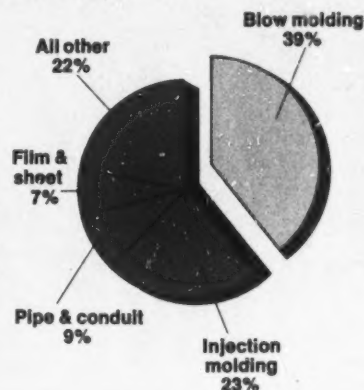
slower expansion in the general economy, which has become the controlling factor in plastics growth.

Production of HDPE nevertheless likely will reach 6.4 billion lb in 1985, and possibly higher, setting a new output record for this resin. Further gains in production may be limited by a lack of capacity. At the beginning of 1985, capacity, exclusive of that which could be shifted from making LLDPE, was estimated at 6.5 billion to 6.8 billion lb a year. An additional 2.5 billion to 3.5 billion lb of capacity or more is used to make LLDPE. A sizable fraction of that capacity could be switched easily to make HDPE.

If production of HDPE reaches 6.4 billion lb this year, and if firm capacity is counted at 6.8 billion lb, then plants will be running at almost 95% of name-plate capacity—in effect, all out. Probably some additional production will come from plants converted to make LLDPE. And some small relief for domestic demand also could come from a decline in exports during 1985, perhaps adding 50 million to 100 million lb to the domestic supply.

Development of the blow-molded bottle markets through better resins and high-speed machines has been behind the relatively fast growth in demand for HDPE. As one result, the resin has taken nearly all of the 1-gal milk bottle market. A move toward the half-gallon-size market is

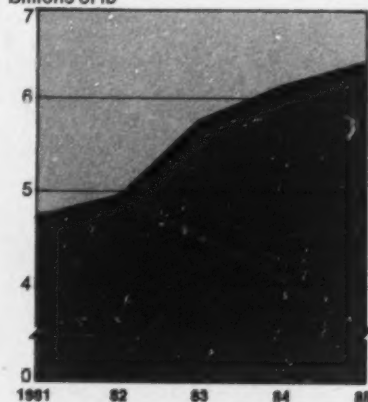
Consumption



Source: C&EN estimates

Production

Billions of lb



Sources: SPI Committee on Resin Statistics, C&EN estimates

slower than was the shift to the 1-gal size.

The slower move into other milk and juice container sizes had been thought to be a cause for a slowing in the demand for blow-molding resins. But in 1984, the shift toward HDPE for motor oil containers began, and that helped to drive demand in this use area again. The potential to replace metal/composite cans for motor oils likely will keep demand for HDPE growing for quite some time.

Other uses, such as injection molding of many kinds of fabricated items, also keep pushing demand for HDPE. Mold development continues to extend injection molding. Film, pipe, and conduit show good growth rates.

products, and industrial products each accounting for about 10%.

Many other thermoplastics, ranging from complex man-made polymers to modifications of natural products such as rosins, are produced in varying quantities. Production and sales data are available for some of these plastics. For example, production of various acrylic resins for uses other than making fibers totaled nearly 1.4 billion lb in 1983, the last year for which data are available from the International Trade Commission.

Other large-volume miscellaneous thermoplastic resins include the various petroleum hydrocarbon resins, production of which amounted to more than 250 million lb in 1983, according to ITC. Output of modified rosin, rosin esters, and modi-

fied rosin esters was close to 400 million lb in 1983. Production of nonnylon polyamide resins was much smaller, at about 60 million lb, as was that of polyterpene resins, at 35 million lb.

A large number of miscellaneous thermoset plastics also are produced. Smaller companies often make these materials for captive use in their products such as coatings and adhesives. The various alkyd resins dominate this group of thermosets. More than 80% of the 720 million lb of alkyd resins produced in 1983 were based on phthalic anhydride. Much smaller-volume plastics in this group of thermosets are the silicones, polybutadienes, and glyoxal-formaldehyde resins, among others.

Another important thermosetting plastic resin group is polyurethanes.

No authoritative sources of production data for these plastics are available because of the wide diversity of producers. Polyurethane foams are relatively easy to make by combining an isocyanate and a polyol. These two components can be either batch mixed or metered out and put into some type of control for size and volume. Many times, additional materials such as blowing agents or cell formation controls are added. More-sophisticated production methods continue to be developed, but these haven't reduced the number of producers very much, as is the case for many of the makers of thermoplastics.

Most polyurethane foams are classified either as flexible or rigid. Of the close to 2 billion lb of polyurethane foams sold or captively con-

Polypropylene looks strong, but lags in profitability

Polypropylene has all the characteristics of a profitable polymer. Consumption of the resin is up quite strongly over that of a year ago. Capacity currently is being utilized at nearly the effective limit. New developments in uses and fabrication techniques are announced frequently. And manufacturing technology continues to be improved in areas such as catalyst development.

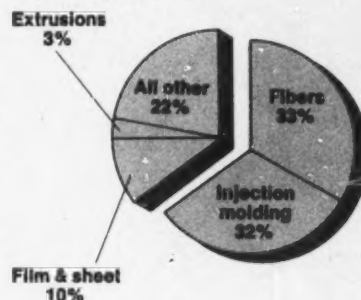
But profitability isn't all that high, according to producers. Clearly, prices haven't advanced as they might have for a resin whose production plants now are running close to all out. Future expectations, as they thwart ef-

forts to increase actual selling prices, might be a reason for low profitability. Inventory reduction also could be another reason. Propylene prices, although not controlled at all by demand for making polypropylene, could be hurting profitability by staying above ethylene prices and by reducing profit to producers who are trying to be competitive with polyethylene.

Even with a lack of profitability, production of polypropylene again will increase at an above-average rate for plastics in 1985; it likely will be up about 7% to 5.2 billion lb. This production will come from a nameplate capacity of about 5.6 billion lb for the year. Capacity will rise about 150 million lb during 1985, most of which, but not more than 100 million lb, will be coming from a plant with an announced nameplate capacity of 175 million lb built as a joint venture of Union Carbide and Shell Chemical in Seadrift, Tex., and using the Unipol technology and the Shell catalyst. This plant, after getting through the usual technical difficulties, is expected to produce for half of the year. The rest of the expected increase in capacity for this year will come from debottlenecking efforts, including the use of improved catalysts, by several of the other producers.

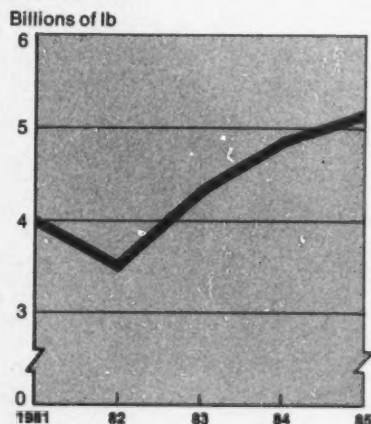
Using those forecast production and capacity figures, average operating rate for the year will be 93%—very close to the effective operating rate, especially if time is lost in making changes to different grades.

Consumption



Source: C&EN estimates

Production



Sources: SPI Committee on Resin Statistics, C&EN estimates

Two possible avenues could be used to avoid a polypropylene supply crunch from developing this year. One, according to an industry source, is the use of new catalysts and other plant improvements that could increase effective capacity 5% or so, much more than the usual 1 to 2% obtained in debottlenecking programs. The other way is to cut net exports of polypropylene. Total exports of the plastic were off slightly in 1984, a possible indication of a larger change due in 1985.

A decline in net exports of polypropylene would allow domestic markets to expand faster. These markets likely could take much more resin in such end uses as injection-molded items and fibers, the current large applications at about a third of total demand each. Some smaller applications such as blow-molding of containers are rising even faster, but from quite small bases.

sumed in the U.S. in 1984, flexible foams make up about two thirds, according to SPI's Committee on Resin Statistics. This production barely topped the previous high in production for various forms of polyurethane set in 1979. A few other forms of polyurethanes, such as elastomers and coatings, are made.

The economy quite strongly influences demand for polyurethanes because about 45% is consumed in the manufacture of furniture, bedding, and floor coverings with another 20% going into construction. Transportation equipment takes more than 15% of consumption. As might be expected, flexible polyurethane foams account for most of

the uses in furniture and transportation. In construction, rigid polyurethanes are used mainly in commercial roofing and wall sheathing.

Polyurethanes account for about two thirds of the sales of plastic foams going to builtup and singleply membrane roofs, with polystyrene and phenolic foams taking the rest. The high heat insulation value of polyurethanes and their chemical kin, the polyisocyanurates, is helping move the board forms of these materials into the renovation business as well as into new construction.

The furniture markets for polyurethanes are growing at a slower pace, partly because of their size.

Fashion in furniture, as well as the economy as it influences housing starts, partly affects demand. The outlook for this use of polyurethanes and for the much smaller carpet and carpet underlay use remains one of slow growth.

The forecast for slower growth in furniture uses of polyurethanes suggests a repeat of the early 1980s when these uses, as well as transportation uses, declined and held total demand down 10 to 15% for three years. Plants making the components for urethanes were shut down for varying periods. Then in 1983, a recovery brought demand back to prerecession levels. The current slowing may not be perma-

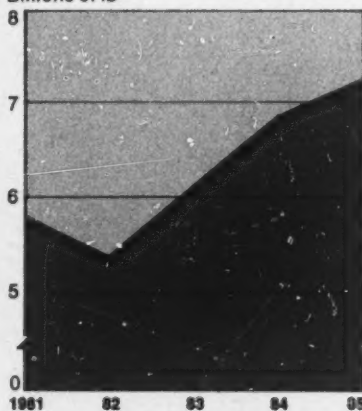
PVC use is growing well, but worries of slowdown persist

As polyvinyl chloride producers ponder whether monthly production has passed its peak for this year, they are wondering if a slowdown will occur during the second half of 1985 and how bad it might be if it does occur. A reasonably strong second half would give annual production a boost of 4 to 5% over 1984 to about 7.2 billion lb.

So far, demand has been showing the growth needed to attain that forecast. The gain, however, will be but a bit more than half of 1984 growth, a year in which prices dropped significantly during the second half.

Production

Billions of lb



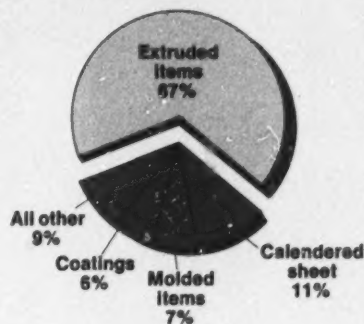
Sources: SPI Committee on Resin Statistics, C&EN estimates

If 1985 PVC production does total 7.2 billion lb, the plant nameplate capacity of about 8.5 billion lb will be operated at an average rate of 85%. That rate harkens back to the late 1970s when new records for production were set each year and when operating rates exceeded 90%. As is the case for other major-volume plastics, the operating rate for plants can only be guessed because of the small variables in capacity that often are not picked up for some time after they are put in place. Just as are units for making other resins, PVC plants are continuing to be streamlined by technical innovations and other debottlenecking efforts.

Along with plant operating rates, producers also are looking hard at pricing of PVC. After a good start in early 1984, prices plummeted in the fall because of inventory cutting. Again in early 1985, prices rose substantially from about 20 cents a lb to about 30 cents a lb, with considerable variation depending on grades and types. But recent efforts to increase prices have been less effective, partly because chlorine prices have leveled off after a series of increases. As with further gains in monthly production, additional price increases seem less likely during the second half of this year.

The PVC production and price increases derive from further recovery in building and construction, heavily weighted toward increases in housing

Consumption



Source: C&EN estimates

starts so far this year. The building/construction uses of PVC account for close to 60% of total consumption in the U.S. Most of these uses are extrusions of one kind or another, with pipe and conduit by far the largest. Other important and relatively faster-growing extrusion uses in building are siding and window frames. Home and commercial building also absorbs large shares of the calendered sheet made of PVC as floor coverings.

PVC production during the first half of the year has jumped because of the building of inventories of resins to be fabricated into the various components used in construction. Estimating the final demand for PVC in these uses continues to be difficult for the industry. Errors in making these estimates in 1984 led to the price debacle late in the year that made annual profits look anemic.

ment, especially if construction uses continue to increase as they did during the recession and as they are forecast to do this year.

This cycling of demand may be behind Dow's recent purchase of Upjohn's polyurethanes operations. Dow will get a 270 million lb-a-year methylene-diphenyl diisocyanate plant at La Porte, Tex., foams manufacturing facilities, an equipment manufacturing plant, and interests in various foreign polyurethane materials plants. These operations are expected to fit in with polyurethane materials businesses that Dow has had for some time.

Changes in ownership of plastics operations have been increasing in the 1980s. Another recent example

is Shell's selling its polystyrene business to Huntsman Chemical. These changes, according to some industry sources, come about partly because of changes in the end-use patterns for plastics. Not only do the uses of individual polymers change, but the uses of plastics in general.

The total volume of plastics consumption has risen to such a large extent that some of these changes in the end-use pattern are obscured by the industry's size. Among the nine major use categories, two have declined significantly in their share of the total market. They are exports and adhesives, inks, and coatings. These declines largely have been made up by bigger shares going to packaging and construc-

tion. Somewhat unexpectedly, the share of plastics in electrical/electronic applications has declined slightly during the past five years.

Packaging at more than 29% of the market for plastics continually adds to both the volume and fraction of use. That puts a whopping 13.5 billion lb or more of plastics into a variety of packaging uses during 1985. More than 99% of that volume will be thermoplastics, with low-density polyethylene accounting for the largest single share, at 40% or more. In recent years, low-density polyethylene has been losing part of its packaging market, mostly at the expense of its high-density relative, which now accounts for about 26% of the packag-

Polystyrene output expected to set new record

This year polystyrene could fulfill the optimistic expectations of many. Production likely will top the record high of slightly more than 4 billion lb of both straight and rubber-modified polystyrenes. Profits for producers could improve as large increases in benzene raw material costs are passed on and as new grades and types of the polymer with higher prices are introduced.

Following a big drop in 1982, production of polystyrene has been rising steadily. A combination of factors has caused this upswing: the large improvement in the general economy, better export sales (although these may be changing), and new polymers with improved processing characteristics.

If production of polystyrene increases to about 4 billion lb this year, plant capacity, estimated at 5.5 billion lb at the beginning of the year, will run at an average rate of just 73%. This relatively low plant utilization, when compared to rates for other major-volume plastics, will keep this segment of the plastics business very competitive. However, the operating rate could be the best of the 1980s so far by a slight margin, even with about 150 million lb of capacity being added during 1984 through various debottlenecking programs.

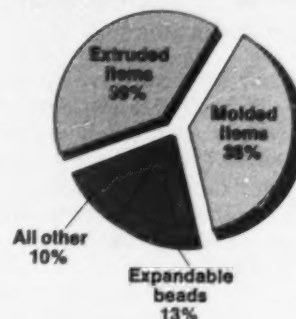
Actual operating capacity differs considerably from the nameplate total. A

large portion of capacity was shut down during the 1982 recession, and although not yet scrapped, some may never run again. Therefore, the operating rate for plants now running is well above the estimate for the fraction of existing nameplate capacity being used.

To achieve a production growth of 5% in 1985, much of the development work on polystyrenes during the past few years will have to bear fruit. More market share from other polymers and from other materials will have to be captured in its major end-use areas, such as packaging, and in many smaller but higher-performance requirement products such as cabinets and housings for electronic equipment.

As is happening with other polymers, the grades and types of polystyrene are being expanded rapidly as producers tailor their lines to capture demand. Packaging, at well over 40% of polystyrene consumption, gets much

Consumption

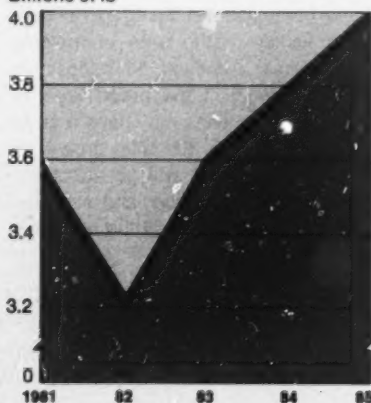


Source: C&EN estimates

attention. Emphasis is on improved processability to allow molders and extruders to increase throughput rates, and on polymers to permit making even lighter containers and to reduce finishing operations. Some of these same desired properties could allow additional capture of packaging markets still served by glass, metals, and paper.

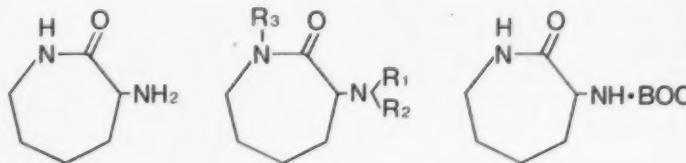
Production

Billions of lb



Sources: SPI Committee on Resin Statistics, C&EN estimates

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Phenolic resins—economy is key to fortunes

Phenolic resin production may stall in 1985, increasing just marginally, if at all, over production of last year. Pricing, and therefore profitability, will be sluggish at best. No additional producers are expected to join the business. Nor are any large producers expected to drop out this year.

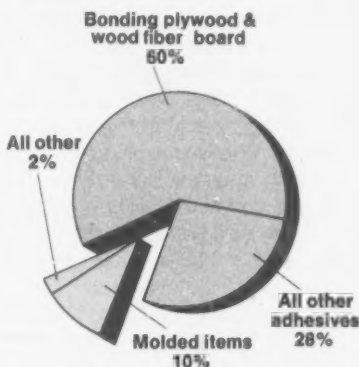
The performance of phenolic resins, a mature business, reflects the economy's effect on its major end uses—construction. More than 60% of consumption is as adhesives for products such as plywood, particle board, and insulation binders. Last year, this big industry again slowed, causing production of phenolic resins as reported on a gross weight basis actually to decline, but less than 1% to about 2.5 billion lb, according to SPI's Committee on Resin Statistics. Some recovery is under way in construction, but some forecasters question whether

the upturn will continue throughout all of 1985.

No estimate of the U.S. capacity to make phenolic resins can be made because of the wide variations in size of plants, the blocked operations in which other resins are made in the same reactors used to make phenolics, and the wide diversity of resins that can be considered phenolics. For the same reasons that capacity for this segment of the plastics industry can't be estimated, an estimate of plant operating rate is unimportant. Small producers who can switch from one resin to another and who make phenol resins for captive uses have little concern about the rate at which their units operate but are concerned about selling the products made using the resins.

Most of the larger-volume producers of phenolic resins, however, operate on a generally continuous basis. These producers either sell or require the resins for use in making construction materials and operate to meet sales demands, which are quite seasonal. Inventories of construction products are of considerable concern to these large producers. Changes in building materials inventories affect pro-

Consumption



Source: C&EN estimates

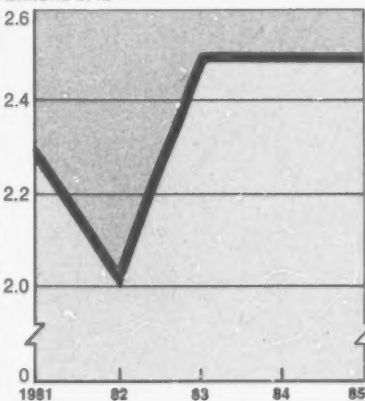
duction rates, so phenolic resins producers try to regulate their production by making other bonding and adhesive resins as well as molding and other types of resins.

On a gross weight basis, phenolic resins made for use in bonding plywood account for more than half of sales and captive use. Resins used in bonding fiber board and insulating materials take about another 20% of total sales and captive uses. If other smaller construction industry applications are included, about three quarters of phenolic resins production goes into this single industry. As a result, many phenolic resins producers have close ties to construction or are primarily producers of building materials. The fortunes of these materials, as they develop from home and commercial construction, therefore determine how the demand for phenolic resins grows.

Many small uses of phenolic resins have been and are being developed, most widely in the area of molding compounds. Although an occasional phenolic resin in the broad area of miscellaneous uses may have a large fractional growth, the total growth of phenolics probably will be about the same as that for plywood and, similarly, will depend on how well the economy performs.

Production

Billions of lb^a



^a Gross weight. Sources: SPI Committee on Resin Statistics, C&EN estimates

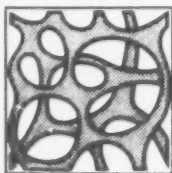
ing market. Much of the remainder of thermoplastics in packaging uses goes to polystyrene at more than 12%, polypropylene at nearly 8%, and PVC and thermoplastic polyesters at about 5% each.

Various kinds of flexible packaging,

mainly bags, take nearly half of the volume in packaging. Bottles and the like take another 20%. Food containers, including disposable cups, have been slipping in their share of packaging and now are down to about 12% of the total.

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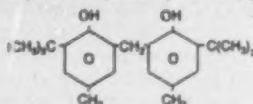
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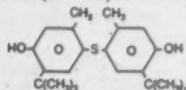
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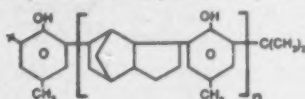
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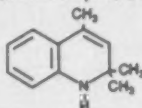
ULTRANOX 236 Antioxidant
4,4'-thio-bis(2-*t*-butyl-5-methylphenol)



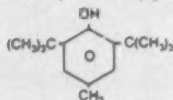
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Product Report

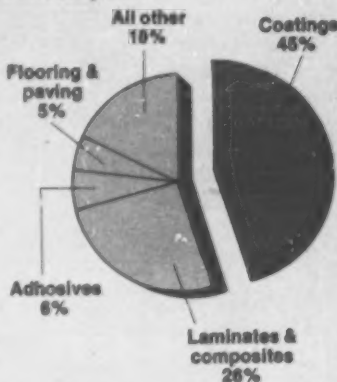
Epoxy still a question mark for 1985

Epoxy resins output rose more than 20% during 1984, a year of substantial economic growth. The major end uses of epoxy resins—coatings and laminates—tacked on the largest gains. Although production slowed some early this year, the considerable seasonality in epoxy resin output makes it too early to call as yet.

Epoxy resin production last year reached 406 million lb, exceeding 1983 production by 72 million lb, and topping the previous record for production of 361 million lb set in 1979. But output also dropped to 286 million lb in 1982 during the recent recession. The relatively wide swings in production characterize this segment of the plastics business as one strongly influenced by the level of industrial production. Most epoxy resins eventually end up in products whose demands rise and fall with the economy—beverage cans, automobiles, and electronic devices, for instance.

Production of 406 million lb last year certainly helped capacity utilization, but did not seriously strain capacity. During 1984, Ciba-Geigy brought on stream some net additional

Consumption



Source: CAEN estimates

capacity, bringing the total for liquid and solid unmodified resins to about 520 million lb. The average capacity available for utilization last year was more than 450 million lb, making the operating rate close to 90% of nameplate.

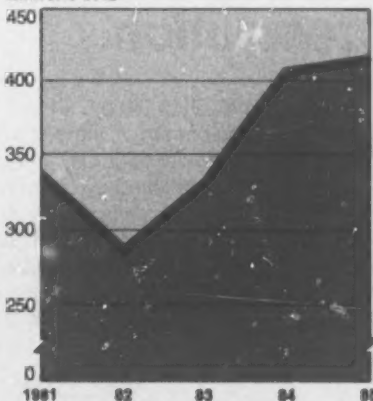
With capacity running at rates higher than 90%, some price increases for epoxy resins were announced in late summer. The increases were not large and prices fell back. If the seasonal upturn in demand continues, then price increases may be tried again soon.

In 1984, about 45% of U.S. consumption of epoxy resins went into various kinds of protective coatings. About half of epoxy coatings were used as automotive finishes and as beverage can coatings. Neither of these uses is expected to grow very fast and both may be subject to downturns in the economy.

Nearly 20% of epoxy resins demand went to fiber-reinforced laminates used in making printed circuit boards. Epoxy resins are expected to remain the material of preference for these boards, but increasing performance demands could cause board producers to shift to other polymers later in the 1980s.

Production

Millions of lb



Sources: SPI Committee on Resin Statistics, CAEN estimates

Another big market for plastics, building and construction uses (about 22%), closely follows the economy. These uses turned down during the early 1980s when home building fell off drastically. Roughly half of plastics consumption in

these uses is in materials for structures and more than 35% more are used in pipe, conduit, and fittings.

As might be expected from the size of pipe demand, PVC accounts for about 40% of the resins used in construction. Phenolics, because of



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Product Report

their extensive use as adhesives and bonding agents, hold second place at 23%. Urea/melamine resins are third at 10%. Thermosets hold about 40% of the building/construction uses, in contrast to their use being minuscule in packaging.

The construction recovery last year boosted plastics used in pipe, conduit, and fittings to a new high of 2.85 billion lb, 4% more than the previous record in 1979, according to SPI's thermoplastics pipe and fittings report. PVC accounted for about 85% of shipments of plastic pipe, conduit, and fittings. Some 42% of plastic pipe was used to carry fluids under pressure. Another 28% was for sewer and other drainage piping. About 15% was for drain, waste, and vent piping in individual buildings. And 13% was used as conduit.

Although acrylonitrile-butadiene-styrene (ABS) resins accounted for only 5% of pipe shipments, they comprised more than 13% of the resins used in fittings. Even so, the share of the fittings market going to ABS continues to decline as does ABS use in the pipe market.

Until recently, consumer and institutional uses of plastics had been on hold. These applications have begun to grow again as product development gains new uses. Long-term uses such as in table and kitchen wares and in toys and sporting goods have been either not growing or have been declining.

Thermoplastics comprise 95% of the plastics going to consumer/institution uses, with polystyrene, at more than 20% of the total, being the largest-volume of these. Polypropylene accounts for 15% of this total, with both HDPE and LDPE just behind.

The electrical/electronic uses of plastics have been trending downward, partly because of downscaling in the size of this kind of equipment. Appliance uses of plastics have been hovering near 800 million lb for the past five years, but use in communications equipment has been declining. The miscellaneous, small-volume, high-priced thermoplastics and thermosets have the largest share of resins made into electrical/electronic items. This share, at 26% of the total, indicates

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Paul A. Hedin, Editor
U.S. Department of Agriculture

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CONTENTS

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Product Report

the performance demands of these industries' products. PVC, LDPE, and polystyrene at 12 to 15% each are other important resins in these applications.

Both transportation and furniture/furnishings uses of plastics have been growing very little over the past five years. These outlets each take about 5% of total plastics consumption, but with variations as car and house sales rise and fall. Components for motor vehicles take about 85% of plastics used in the transportation category, with boats and recreational vehicles accounting for most of the rest. Unsaturated polyester and phenolic resins make up most of the 27% share of this market captured by thermoset plastics. Polypropylene, because of its fabrication to fibers, receives about half of the consumption of plastics in the furniture/furnishings market.

Adhesives, inks, and coatings made from plastics have declined in their share of the market, now to

about 4% of the total. The decline in volume can be attributed in part to improvements that require less polymer to be used. Thermoplastics take about 70% of these markets.

In considering all these categories of plastics markets, many minor-volume, but very important, uses are obscured, and their novelty is hidden. For example, medical uses are growing rapidly from a small base, often are very specialized, and in many cases require much special processing.

Among these small hidden uses—some larger than the high-purity polymers for the medical field—are the emerging new uses for plastics. Such new uses often were developed for very specialized reasons and further development led to other uses that have ballooned in their demand for a plastic. One example often cited is the growth of polyester resins now widely used in making bottles for soft drinks, food, and other products. Polyester may go into bottles for many other prod-

ucts as more development work bears fruit.

Development of plastics to fit untapped end-use markets is leading to more complexities in the makeup of plastics. Terms borrowed from other industries, but new to the plastics industry, are appearing much more frequently—for example, alloys, blends, and composites. These terms define forms of plastics aimed at meeting demand for specific uses that previously couldn't be handled by plastics. Examples are many, including structural parts of highly stressed products such as aircraft, lightweight bicycles, highly heat-resistant plastics that have costs low enough to permit use in baking or other cooking utensils for the home, or in bottles that minimize transmission of oxygen and light as glass does now.

Making these new forms of plastics usually proves to be difficult. Often special plants or processing units have been built to make them. Several of the major producers of

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Polyester production growth slated to slow

Production growth of unsaturated polyester resins will taper off this year after two good years of recovery from the recession-caused decline of some 13% in 1982. If the economy remains healthy for the rest of 1985, production of these resins is expected to be up 2 to 5%. But if the economy slips, production surely will fall as it has in the past when disposable incomes declined and sales of luxury goods such as boats and other recreational vehicles fell precipitously.

Production of unsaturated polyester resins managed to set a record last

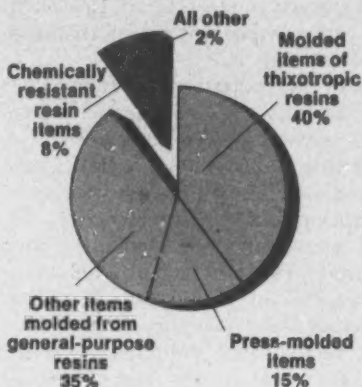
year at 1.23 billion lb, up almost 15% from 1983 and slightly more than the previous high of 1.21 billion lb in 1978.

If forecasts for this year hold, output of unsaturated polyester resins again would set a record at 1.25 billion to 1.30 billion lb. That level of production would not strain capacity, which has been holding at about 1.6 billion lb. Nonetheless, capacity remains elusive because of the large number of dual-purpose reactors used by the industry to make these resins. The same reactors can be used to make other kinds of resins depending on the current demand on a producer. As is the case for other kinds of thermoset plastics, some of the production facilities may be left shut down for long periods during a year. Producers can do this because it is easy for them to start up reactors and because the capital investment required for reactors and auxiliary equipment is low.

Most unsaturated polyester resins—more than 75%—are fabricated with a reinforcing material, usually glass fiber, to offset their brittleness. Demand for these reinforced plastics, including the weight of the fibers and fillers, is forecast to grow about 5% during 1985.

About 40% of the reinforced applications, on the basis of the polyester resin alone, are in the construction area. Construction uses split roughly three ways: in corrosion-resistant tanks, pipe, and fittings; in bathroom fixtures;

Consumption

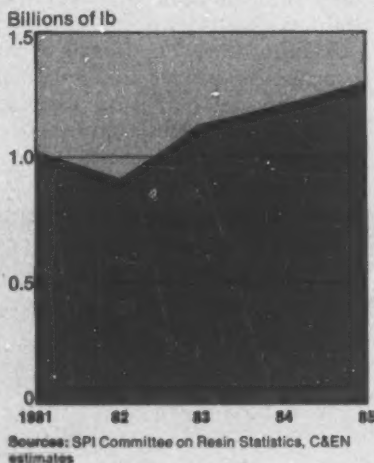


Source: C&EN estimates

and in miscellaneous construction items. Transportation equipment ranks nearly as large on the basis of resin consumption. About two thirds of the transportation uses are boats and marine accessories. The other third is in automotive components. The remainder of reinforced polyester applications range widely from appliance parts to toys.

Nonreinforced polyester resins go largely to make cast items such as synthetic marble used as vanity tops in homes. The other big use is in auto body putty. Numerous small miscellaneous uses are coatings, adhesives, and bonding agents. None of these uses of polyester resins in the non-reinforced area are expected to grow very rapidly this year.

Production



plastics, such as Celanese, Dow, Du Pont, and General Electric, have completed facilities within the past year to make special alloys of plastics.

This segment of the plastics industry is fast-growing, probably more than 15% annually. According to Business Communications Co., a market research firm in Stamford, Conn., 1983 production of alloys and blends of plastics was about 300 million lb, worth more than \$400 million. Other marketers have estimated 1984 production in excess of 350 million lb with a value of more than \$450 million.

The basic resins that are involved in new alloys and blends cover most of the large-volume plastics, such as the polyolefins, polystyrene, and

polyesters, but also include the smaller-volume polymers, such as specialty nylons, epoxies, and phenolics. Frequently, a reaction is involved in making an alloy; sometimes a copolymer results from grafting reactions.

As the plastics industry evolves, with its broad potential variety of alloys, blends, and other new forms made for special uses, it will become increasingly difficult to estimate output and use of plastics and monomers. Even now, many estimates of the production of plastic resins include weight of comonomers used with the basic monomer. For example, linear low-density polyethylene production estimates include the weight of the other olefins polymerized with ethylene,

thereby overstating ethylene consumption slightly.

In time, after process developmental work, some specialty or engineering plastics likely will become commodity plastics. The result will be substitution of plastics in markets already held by plastics and further penetration in markets held by metals, glass, paper, and other materials. The slowing in fractional growth of the large-volume commodity plastics may be offset by higher growth of the specialty plastics. With the number of specialty plastics and variations of commodity plastics increasing so rapidly, the total growth of the plastics industry will remain well above that of the general economy—even if it's not so rapid as it was 20 years ago. □

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for the chemical
industry Page 22

CHEMICAL & ENGINEERING **NEWS**

JUNE 10, 1985

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■ EPA administrator leaves most of the regulation of air pollutants to state and local governments. **Page 4**

■ Complex Carbohydrate Research Center is cooperative venture of USDA and the University of Georgia. **Page 5**

■ Pesticide Action Network issues list of "Dirty Dozen" pesticides, urges alternatives be used. **Page 5**

■ Argonne's ATLAS is world's first superconducting accelerator for heavy ions. **Page 5**

■ House subcommittee says HHS violates the law by refusing to ban dyes that have been found to cause cancer in lab animals. **Page 6**

■ Jeremy Rifkin wins suit to halt construction of aerosol toxin test laboratory at Army's Dugway Proving Grounds. **Page 6**

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Magnesium production and consumption increased in 1984, giving it an edge over other segments of the metals industry. **Page 11**

Government

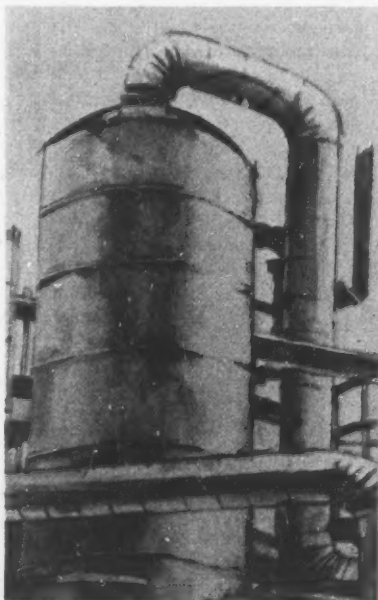
High-tech entrepreneurship on a small scale is expanding with help from tax breaks, political interest. **Page 14**

Technology

Using beneficiation and hydrogenation, eastern oil shales could be a good energy source at competitive prices. **Page 17**

Second-generation microbiological assay system speeds up the process for analyzing potency of antibiotics and vitamins. **Page 19**

Two new series of Sartorius automatic analytical balances, priced from \$1695 to \$2995, available in U.S. **Page 19**



Facts & Figures

Neither the best of times nor the worst of times, 1984 saw some recovery for the U.S. chemical industry. C&EN's annual survey presents statistics that measure the industry's performance in both the U.S. and foreign countries. **Page 22**

Growing Pains Give Biotechnology Firms Mixed Results in Quarter

Costs of commercialization lead many companies to seek financing through additional equity sales, more extensive licensing, and new ventures

David Webber, C&EN New York

First-quarter 1985 financial statements of biotechnology-based companies display a broad spectrum of performance. In contrast to 1984, when most of a group of 16 representative firms reported strong revenue increases each quarter compared to the year-earlier period, only nine of the companies had year-to-year revenue gains in this year's first quarter.

Most of the firms in the group are laboring to make the transition from research house to integrated manufacturing and marketing concern. Some, like Genentech, the biggest of the group, are still grooming development-stage products or awaiting regulatory approval for others. Consequently, most of their income still comes from research and development fees and, though diminished by falling rates, interest income. Others, wanting freedom to concentrate on proprietary product research, have taken the risky step of reducing their contract R&D commitments; as a result, revenues have dwindled.

Still others have left the familiar laboratory environs to tackle manufacturing and marketing. There, in some cases, unexpected costs and marketplace surprises have taken their toll on finances. Almost all members of the group, having lived off the cash amassed through their stock issues of several years ago, have felt the need to seek new capi-

tal. Some have been successful; some are still searching. Except for those that have bolstered their cash and marketables through equity sales and joint ventures, they have generally watched their interest income decline.

The diversity of results stems in part from this multiplicity of factors, factors essentially having to do with what particular stage a particular company now occupies in its movement toward commercialization. The differences in performance also reflect the differences in the individual firms' goals and the technologies they employ.

Some of the group, like Genentech, Cetus, and others, want to be pharmaceutical producers. Although recombinant DNA technology is most advanced in that area, significant delays to product launch stem from the need to conduct clinical trials and meet other regulatory obliga-

tions. Other firms aim to market agricultural products based on plant biotechnology. The principal methods in use—recombinant DNA, cell culture, and tissue culture—are less advanced in that area, and major products are consequently further from commercialization.

In terms of product sales as a percentage of all revenues, the furthest along are, in general, those companies using monoclonal antibody technology in diagnostics for humans and in both diagnostics and therapeutics for livestock. Such firms, like Hybritech and Monoclonal Antibodies Inc., continue to report steady, large gains in sales. The hitch for these companies is more long term: The ultimate market—for their current mix of products, at least—is expected to be much smaller than that for human therapeutic or crop products derived through biotechnology.

Fewer firms had higher revenues in first quarter

	FIRST-QUARTER 1985 ^a					
	Revenue ^b (\$ millions)	Earnings ^c	Change from 1984		Profit margin ^d	
			Revenues	Earnings	1985	1984
Amgen	\$ 3.350	\$-1.718	89%	def	def	def
BioTechnica International	1.225	-0.758	204	def	def	def
Bio-Technology General	0.285	-0.872	50	def	def	def
Biogen	4.864	-4.976	-19	def	def	def
California Biotechnology	2.000	-0.109	0	def	def	4.4%
Centocor	4.480	0.497	77	8183%	11.1%	0.2
Cetus	12.628	0.211	5	95	1.7	0.9
Collaborative Research	2.215	-1.060	11	def	def	def
Damon Biotech	0.675	-2.995	-52	def	def	def
Genentech	20.164	0.715	32	86	3.5	2.5
Genex	4.795	-2.300	-11	def	def	def
Hybritech	11.964	0.366	97	165	3.1	2.3
Immunex	0.611	-1.276	-7	def	def	def
Molecular Genetics	2.339	-0.479	-10	def	def	def
Monoclonal Antibodies	1.525	-0.393	133	def	def	def
Ribi ImmunoChem	0.181	-0.188	-31	def	def	def

a For three-month period ending closest to March 31. b Includes sales, contract research, royalty, and interest revenues. c Excludes extraordinary credits. d After-tax income as a percentage of revenues. def = deficit.

For all members of the group, increasing attention was paid to controlling costs. Spurred by the looming threat of a long-predicted industry shakeout and increasing competition from the large chemical and pharmaceutical corporations that are conducting biotechnology research themselves, the smaller companies are faced with the need to spend more on R&D, manufacturing facilities, and marketing forces at the same time that their cash reserves may be shrinking and product or royalty income is still meager. For that reason, several firms traded both proprietary positions and equity for a little more financial security.

California Biotechnology, for example, which recorded no gain in revenues along with a loss compared to a small profit in the same quarter a year earlier, sold 1 million shares, or about 15% of its common stock, to American Home Products, the health-care-products giant, for \$12 million in mid-April.

"American Home's equity investment will augment Cal Bio's capital position, thereby accelerating the company's ability to enlarge its research activities and to develop and exploit its creative capacity to discover and introduce new therapeutic products," said William G. Baker Jr., chairman of the Mountain View, Calif.-based company.

At the same time, California Biotechnology granted American Home Products' Wyeth Laboratories an exclusive world license to market any cardiovascular and diuretic therapeutic agents produced by a joint research program to be established between the two operations. The particular object of the joint R&D effort will be the further development of Auriculins, Cal Biotech's version of a hormone secreted by the atrium of the heart. The company says Auriculins has shown promising results in lowering blood pressure, reducing water and salt from the body, and enhancing the efficiency of the kidneys.

Genentech, South San Francisco, boosted its current assets 148% through two stock sales during the first quarter. One, a public offering of 1.15 million shares of common stock, netted \$50 million. The sec-

ond, a private placement, transferred just under 5% of the company's outstanding shares to Boehringer Ingelheim International for \$40 million. Having raised money this way, cash-rich Genentech can drive better licensing bargains. For example, it reached commercialization agreements covering Europe and Japan for its tissue necrosis factor, a possible anticancer agent due for clinical trials this summer, but kept North American marketing rights for itself.

In the first quarter, Genentech increased revenues 32%, entirely via higher contract R&D receipts. Net income rose 86% to \$715,000.

Cetus reported a 5% increase in revenues, mostly the result of higher R&D contract income from joint ventures with W. R. Grace (Agracetus) and Nabisco Brands. At the same time, the Emeryville, Calif., company kept growth in costs and expenses below 4%.

"The quarterly results are consistent with the company's goal and commitment to maintain its financial strength by using its financial resources prudently," comments Hollings C. Renton, Cetus vice president for finance. "Despite higher costs from human clinical testing, the marginal growth in expenses demonstrates management's efforts to control operating costs."

At Amgen, Thousand Oaks, Calif., current assets declined sharply over the 12-month period ending March 31, contributing to a 41% decline in interest income. At the same time, however, the company raised R&D contract revenues 291% to \$2.6 million and more than doubled product sales to \$92,000. The result: Total revenues climbed 89% in the first quarter.

Damon Biotech, Needham Heights, Mass., posted a 52% decline in revenues at the same time that expenses ballooned 82%. As a result, the firm's first-quarter loss jumped to nearly \$3 million (excluding a federal income tax benefit), up 383% from the same quarter in 1984. Nevertheless, the company, which sells monoclonal antibodies under contract, monoclonal scaleup technology, and is researching human therapeutic applications for monoclonals, remains confident.

"At the close of the quarter, our backlog of monoclonal antibody orders exceeded \$2 million, a record high for the company," comments David I. Kosowsky, chief executive officer. "In addition, our current production rate for antibodies is substantially above last quarter's." Kosowsky also notes that the company has increased its customer base worldwide. In early April, a marketing operation was established in Tokyo.

Concentrating exclusively on the more-developed human diagnostic business, Monoclonal Antibodies Inc. maintained its strong pace of sales increases in first-quarter 1985. Unlike many other young biotechnology-based companies, the Mountain View, Calif.-based firm derives most of its revenues from product sales. In the fiscal year that ended March 31, for instance, 76% of revenues came from sales of proprietary products. In the quarter, revenues rose 133% to \$1.5 million. At the same time, the company pared expenses.

Indications of rough going continue to arrive from Genex, on the other hand. The Rockville, Md., firm, which has focused its expertise on specialty chemicals, lost \$2.3 million in the first quarter, better than fourth-quarter 1984's \$7.5 million deficit, but still worse than the \$2.1 million lost a year earlier. The firm, whose chief product is L-phenylalanine, may have overextended itself in building a \$25 million facility to produce the aspartame precursor. With only one customer, G. D. Searle, plenty of competition, and industry overcapacity, phenylalanine prices have been weak, and volume has not been high enough to maintain a healthy cash flow.

Between the end of 1983 and the end of March 1985, Genex's current assets plummeted to \$8.9 million from \$30.2 million. Now the company is seeking new financing, is selling some undeveloped property, and may have to leverage its new plant in some way. There are also takeover rumors. The company believes the worst is behind it now, however, and projects improvement for the rest of the year—not net income, but at least a lower net loss than 1984's \$7.4 million deficit. □

Magnesium outlook continues to be bright

"A rising star in a sky of falling metals." That's how Pierre Gousseland, chairman and chief executive officer of AMAX Inc., describes magnesium. Certainly its vital statistics for 1984 earn magnesium that accolade.

Although most segments of the metals industry are troubled with overproduction, excessive inventories worldwide, and depressed prices, magnesium is a welcome exception. Primary magnesium production in noncommunist nations rose last year almost 40% from 1983 to 232,100 metric tons. Consumption also increased, rising to 216,000 metric tons last year from 169,000 metric tons in 1982.

Speaking at the recent World Magnesium Conference sponsored by the International Magnesium Association in New York City, Gousseland attributed magnesium's success to its versatility. The metal's light weight, dimensional stability, good machinability, and excellent damping capacity all help to make magnesium an effective alternative to aluminum and other metals, he says.

Claude Y. M. Guillam, sales director of Pechiney Electrometallurgie's magnesium division, adds still another reason. He says that the driving force for magnesium's recovery in 1983 and last year was the strong North American econo-

my. North America accounts for about half of noncommunist countries' magnesium consumption.

With both these factors driving its growth, magnesium is on a roll, with most of the increase in demand coming from die casting and steel desulfurization. Guillam expects this trend to continue for the next five years. He estimates that magnesium consumption in noncommunist countries will increase 4.6% to 226,000 metric tons this year and reach 260,000 metric tons by 1989—20% higher than last year's level.

By 1989, magnesium capacity in noncommunist countries will have grown to an estimated 313,000 metric tons from this year's 285,000 metric tons. This, says Guillam, should be enough reserve capacity to allow for unexpectedly rapid growth in one or more of magnesium's end-use areas.

This reserve capacity could well be needed. Alloying with aluminum now accounts for more than half of magnesium consumption and will remain by far the largest outlet. But Gousseland says that magnesium producers can't continue to depend upon one industry—aluminum—for most of its sales growth.

They aren't. Two other outlets, die casting and steel desulfurization, are earmarked for considerable growth. Producers have devoted a lot of attention to pressurized die casting and now are offering better high-purity alloys to improve corrosion resistance. New applications, says Guillam, crop up regularly, especially in the automotive and electronics industries. He says that magnesium consumption for die casting will increase 20% this year from last year to 36,000 metric tons and will hit 45,000 metric tons by 1989.

Gousseland says that magnesium's future in die casting is bright because magnesium die-casting alloy solves weight and durability problems. He also notes that, because of rising electric power costs, aluminum producers are recycling can scrap into new cans rather than channeling the metal to secondary producers for die-casting alloy. This, he says, could open the door even further for magnesium alloys as the price of secondary aluminum alloys rises.

Aluminum alloying is biggest use of magnesium . . .

Thousands of metric tons	1984	1985 ^a	1989 ^a
Aluminum alloying	118	116	123
Nodular iron	10	12	14
Desulfurization	17	21	32
Chemical/reduction	28	27	30
Pressure die casting	30	36	45
Other structural	6	9	11
Other	7	5	5
TOTAL	216	226	260

. . . and North America is its biggest market

Thousands of metric tons	1984	1985 ^a	1989 ^a
North America	110	113	123
Latin America	8	9	13
Western Europe	67	70	85
Africa/Middle East	2	2	4
Asia/Oceania	29	32	35
TOTAL	216	226	260

^a Forecasts. Note: Primary magnesium consumption in noncommunist countries only. Source: International Magnesium Association

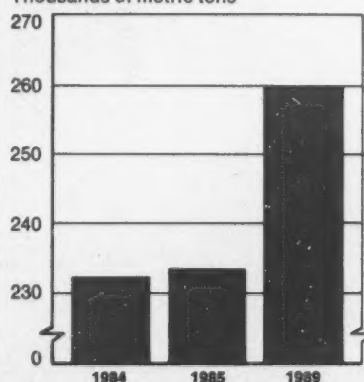
Desulfurization also holds promise for major growth for magnesium. In North America, 70% of hot metal desulfurization is now done with magnesium, according to Gousseland. He believes that by 1988 most North American steel mills will have committed themselves to magnesium desulfurization. So, he says, will a number of European producers.

Desulfurization, in fact, already has become a major market for magnesium. Guillam notes that, as recently as 1982, desulfurization accounted for only 5% of magnesium consumption. It now accounts for 8% and, with a growth rate projected at 15% annually, will account for 12% of magnesium consumed in five years.

Guillam agrees that, although North American steel producers were the first to embrace magnesium desulfurization, Western European producers are now embracing it because of its economic edge. In North America, steelmakers choose pure magnesium powder or pre-coated magnesium granules. In Europe, the technology is somewhat different, says Guillam. There, magnesium powder is combined with a slag or coinjected with calcium carbide powder. □

Magnesium output to grow strongly in late 1980s

Thousands of metric tons



Note: Figures for noncommunist countries only.

Interest Heightens in Development Of Eastern Oil Shale Resources

Coupled with beneficiation and hydrogenation, eastern shale continues to show promise as source of oil as energy shortages approach

Joseph Haggin, C&EN Chicago

Eastern oil shale is among the lesser known alternative energy sources in the U.S., but it may become one of the first big producers of liquid fuels. Despite major legislative and economic hurdles that make the development climate rather gloomy, eastern shale is showing remarkable resilience as the federal budget for fiscal 1986 is pounded into shape.

Eastern oil shale is generally considered to be that shale formed during the Devonian era and lying east of the Mississippi River. The principal deposits are found in Alabama, Indiana, Kentucky, Michigan, Ohio, and Tennessee, with some marginal beds in Illinois and Pennsylvania.

Although it has been known at least since the Civil War, eastern shale has not generated the interest shown in the western shales, mostly in Colorado and Utah. Because of substantial differences between eastern and western shales and because shale development has emphasized western shales, eastern shales have been considered of marginal quality. The recovery technology for western shales is different from that for eastern shales, and only in very recent years has it been realized that although the technologies differ, eastern shale probably has as much energy potential as any other.

Development of eastern shale resources expanded at a time when there was an "oil glut" and a "gas

bubble." The resulting hiatus in alternative energy development has lulled many people into a false sense of security. But that period probably is about over. In testimony before the House Subcommittee on Interior & Related Agencies, Bernard S. Lee, president of the Institute of Gas Technology, warned that there are already signs that the present period of energy surpluses is at an end.

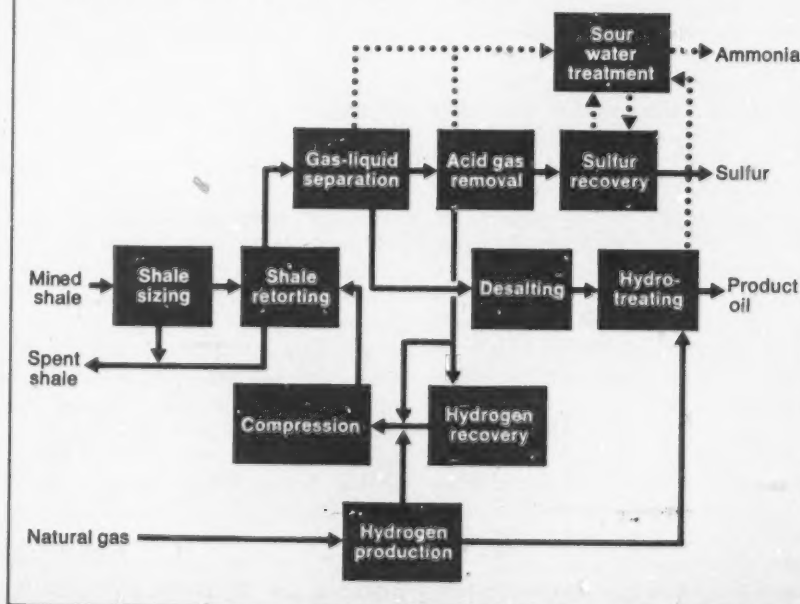
In 1984, the demand for oil and gas began to rise again, and oil imports rose 9%. Lee cites a Department of Energy forecast for a 20% increase in U.S. petroleum consumption by 1995 and a 70% increase in imports during the same period. Legislators appear reluctant to reinforce R&D funding for alternative energy sources. However, a consensus among the professional engineering community leaves little

doubt that failure to increase and develop alternative energy options now could lead to serious problems in the near future.

A typical assessment of the eastern shale potential comes from Jack Clark, consulting engineer for the Mineral Resources Institute at the University of Alabama. Clark sees eastern shale as a developable resource in the next 10 to 15 years, if the effort is begun now. Clark believes that the key to development is beneficiation, although eastern shale also may be processed without beneficiation.

As it now appears, conventional retorting of eastern oil shale could yield 12 gal of synthetic crude per ton of shale. Clark suggests that with beneficiation, yield could be increased to 30 gal per ton. With hydrogenation the yield could be further increased to 60 gal per ton.

Hytort plant mostly uses conventional unit operations



Beneficiation, says Clark, is essentially a matter of grinding the raw shale before retorting and concentrating the organic portions by some process such as froth flotation. The inorganic portions may be returned to the mine without treatment and have no known environmental effects. Clark notes that the penalty for beneficiation is probably less than 100 kWh per ton of shale ground. The subsequently greater yields usually mean there is a net gain because of a more-than-compensating downstream energy requirement. There is also a considerably lower water requirement. Most of the energy saved downstream results from elimination of the need to heat and/or cool a lot of inert material. It's currently estimated that about 75% of the original as-mined inert material can be removed by beneficiation.

Retorting of upgraded shale is further enhanced by hydrogenation to increase the hydrogen-to-carbon ratio. The hydrogen can be obtained from any source, but those of greatest current interest are methane reforming and the water gas shift reaction. The Mineral Resources Institute is developing a process utilizing the water gas shift reaction to provide hydrogen for shale retorting.

A definitive survey of eastern shale resources is not available, but enough is known to allow Clark to project the lifetime of the minable shale resources in the eastern U.S. to be about 500 years, much of it by surface mining. Some of the more liberal estimates suggest that eastern shale oil could compete with a world oil price of \$40 per barrel. With beneficiation of the shale, the shale oil might be competitive at \$30 per bbl. If this appears lower than previous estimates for western shale oil, some of the reasons cited are availability of ample process water in the East and lower transportation costs, with markets for products being nearby.

Clark believes that the greatest current need is for good, integrated processes that use beneficiated shale and hydrotreating. Such processes should be of large scale and must operate continuously. That all boils down to building a demonstration

Hytort can recover large amounts of eastern shale oil

State	Mining area, ^a square miles	Resources, ^b billions of barrels
Kentucky	2050	190
Tennessee	1540	44
Ohio	960	140
Indiana	600	40
Michigan	180	5
Alabama	300	4
TOTAL	6230	423

^a Total area suitable for surface mining. ^b Recoverable by above-ground hydrotreating. Source: Institute of Gas Technology.

plant large enough to identify and remove the bugs and glitches that always come with an enterprise of this type.

The Mineral Resources Institute and other groups are pursuing process development, but the leading contender at the moment is probably the Hytort process. Hytort is being commercialized by Hycrude Corp., a subsidiary of GDC Inc., which is a unit of the Institute of Gas Technology.

In the Hytort process, run-of-the-mine shale is ground and classified. The fraction between 0.125 inch and 1 inch constitutes the feed to the retort. Fines are either returned to the mine or treated separately to generate hydrogen-bearing oils or plant fuels. The coarse fraction is recycled. Shale is fed to the retort, which is a countercurrent, vertical, moving-bed contactor. It operates at elevated pressure, making it necessary to feed the shale into the system as a water slurry. The slurry is dewatered before the shale actually enters the retort, and the water is recycled.

Product gases are cooled and the oil and water are separated by decanting. Other acid gases are removed conventionally, and the hydrocarbon gases are used as a hydrogen source or plant fuel. Hycrude presently assumes that the hydrogen source of preference will be methane (natural gas), although any other source may be utilized. For a 50,000 bbl-per-day Hytort plant about 180 million standard cu ft per day of hydrogen is necessary.

An appealing aspect of the integrated processes is the prospect of

recovering a number of strategically important metals as by-products, including aluminum, iron, cobalt, chromium, manganese, molybdenum, nickel, niobium, uranium, and vanadium. An auxiliary process, suggested for use with Hytort, would acid-leach the spent shale with acid derived from the by-product sulfur. Metal values then would be recovered from the leachate by solvent extraction and precipitation.

A projected Hytort plant producing 50,000 bbl per day of raw oil would cost about \$2.3 billion and have annual operating costs of about \$413 million. A 20% return on investment might be realized at an oil selling price of \$43.20 per bbl. It would take about five years to build the plant, which would have an expected lifetime of 20 years.

As the proponents of western shale have experienced since the 1950s, bringing a process to the marketplace requires the active aid of the federal government, particularly where demonstration plants are concerned. Current Department of Energy funding proposals are keyed heavily to development of western shale, but \$3 million was provided in the fiscal 1985 budget to "expand the eastern shale database." A group of eastern shale proponents has suggested that this be increased to \$9 million in 1986, to \$10 million in 1987, and \$11 million in 1988. These funds would be distributed among fundamental research, advanced research, and environmental studies. Individual states with shale potential would be given considerable discretion in some aspects of the program.

As defined by the program, fundamental research supports new technologies that have potential for better utilizing eastern shale, as well as obtaining basic geochemical data on the resources. Advanced research deals with improving existing promising technology and designing process development units of a size large enough to allow for final scale-up to commercial size.

Advocates of eastern shale development say they have a strong case to make in their request for continued funding. Numerous processes have been developed in bench-scale units by Battelle, Allis-Chalmers,

SISO, Rockwell, SRI International, Cities Service, and others. The availability of water, proximity to mines and markets, availability of labor, relative ease of mining, possibility of significant by-product credits, and minimum environmental upset are characteristics of eastern shale. One process in development, namely the Hytort process, is now actively being commercialized, meaning that the developers are confident enough to put it on the market. □

Unit speeds up vitamin, antibiotic assays

Eli Lilly's Elanco Products Co. division is about to bring out a new generation of its Autoturb microbiological assay system, dubbed appropriately Autoturb II. It is, the company says, "computer ready."

The system automates the process for turbidimetric analysis for potency of antibiotics, vitamins, and related substances. Lilly somewhat backed into being a supplier of the system originally. Looking to its own needs, the company made a prototype of the first model in 1968, with its first production model appearing in 1970. But it isn't waiting for word-of-mouth requests to

get sales of Autoturb II off and running. Elanco is now taking orders for the custom-made units, with delivery to begin in the fourth quarter of 1985.

With the new system, microprocessors are used for control and monitoring. An RS-232C serial port is included for transmission of test data to a user's computer, and there is a built-in blue dye calibration routine. The Autoturb II, Elanco says, operates about 20% faster than the original model.

An antibiotic assay is based on inhibition of the growth of susceptible microorganisms by that antibiotic in an inoculated growth medium. A comparison of the antibiotic activity of a sample with that of a known standard permits the potency level of the antibiotic to be calculated.

For assaying vitamins (or amino acids), a different approach is required. In this case, the medium used is deficient in the substance to be measured.

The Autoturb II consists of two modules—a diluter and a reader. A technician manually prepares test tubes containing the sample and reference standard material. The diluter module then automatically prepares desired dilutions of both with inoculated growth medium. After inoculation, test tubes are incubated to enhance growth of the microorganism. In antibiotic assays, growth is terminated, usually by heat.

The incubated tubes are then placed in the reader module, where turbidity of the killed suspension is measured spectrophotometrically. A user-supplied computer linked to the Autoturb II compares the spectrophotometer readings of sample and reference standard to determine potency of the material being tested.

The Autoturb II can handle 20 samples and standards of four dilutions each—a total of 80 tubes—at one time. Each of several operators can assay 100 samples in an eight-hour day—double the output of manual methods, Elanco says. The company figures that the automated system saves a total of 81 minutes compared with manual methods for each 80-tube test.

Except for bacitracin, which gives

a bias, all antibiotics can be assayed with the Autoturb II system, including cephalosporins. It can also be used for handling vitamins B₁₂, folic acid, niacinamide, pyridoxine (B₆), pantothenic acid, and panthenol.

Price of the Autoturb II is \$49,800. Included are the two modules, one test tube tray for samples, five test tube racks for assays, and one waste trough. □

New Sartorius balance series available in U.S.

Two series of automatic analytical balances from West Germany's Sartorius have been introduced in the U.S. by Brinkmann Instruments Co.

The first series, economically priced for routine work and teaching laboratories, includes a balance of 110-g capacity, readable to 0.1 mg, priced at \$1695. A companion balance reads to 0.1 mg from 0 to 60 g, to 0.2 mg from 60 to 100 g, and to 0.5 mg from 100 to 160 g, priced at \$1875. The 0.1-mg readability can be re-established in any region of the 160-g capacity by pressing the tare button.

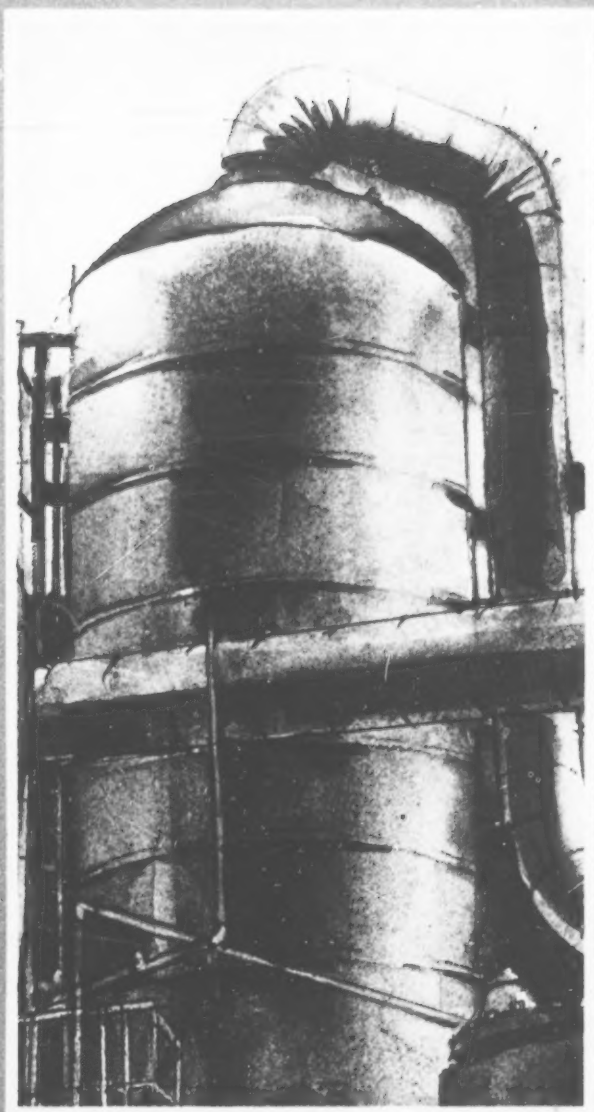
The second series has larger weighing chambers, greater capacities, and finer readabilities for more demanding work. One balance, priced at \$2495, reads to 0.1 mg up to a 200-g capacity. A second, which costs \$2995, reads to 0.01 mg from 0 to 30 g and to 0.1 mg from 30 to 160 g, with the finer readability re-established over the whole capacity range on pressing the tare button. The third balance, with a \$2495 price tag, reads to 0.1 mg from 0 to 100 g, to 0.2 mg from 100 to 200 g, and to 0.5 mg from 200 to 300 g. Again, the finest readability can be selected over the whole capacity range by pressing the tare button.

Brinkmann also offers such options for these balances as RS-232C serial data links, printers, interfaces to many common microcomputers, and external keyboards for remote, dedicated uses like counting, animal weighing, units conversion, statistical analyses, density determinations, and formulation and compounding. □



Technician places test racks ready for assay in Autoturb II reader unit

Facts & Figures



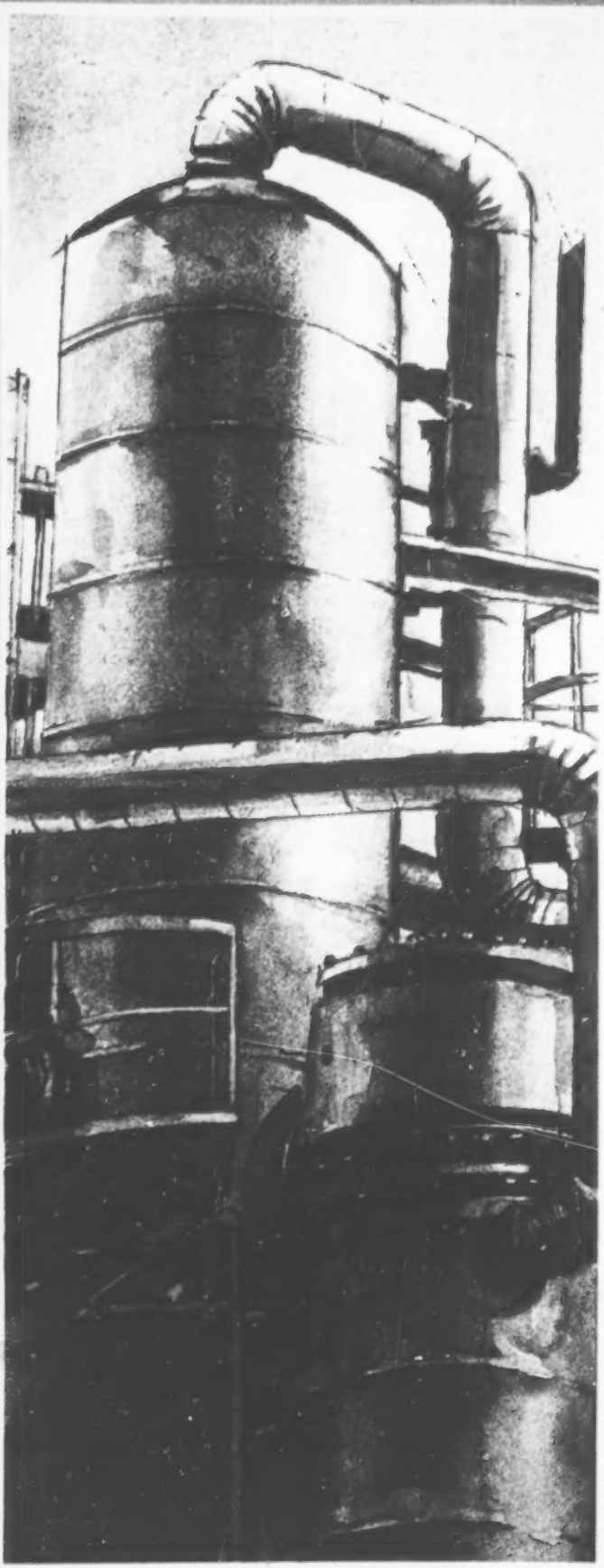
for the chemical industry

For the U.S. chemical industry, 1984 certainly was not the worst of times. But it definitely was not the best of times either.

Production largely has recovered from the lows of the 1981-82 recession. But having done that, further progress has been labored. Growth has slowed perceptively or disappeared entirely. Output during early 1985, in fact, is essentially unchanged from the first part of last year. Sales have slipped and profits are below those of early 1984 for the industry as a whole. Perhaps the past year can best be described as a period of stagnant prosperity or prosperous stagnation.

One of the industry's most intractable problems—in addition to slackening demand in its home markets—is the continued strength of the U.S. dollar relative to major foreign currencies. As a result, exports have lost their competitive edge, imports have been gaining market share, and profits from overseas chemical operations, when translated into dollars, have been increasingly anemic. Although industry executives remain optimistic that renewed economic growth will ease their plight during 1985's second half, the year as a whole is not likely to go into the books as anything much more than a standoff.

The following pages of C&EN's annual Facts & Figures issue present statistics to measure the industry's recent performance both in the U.S. and in foreign countries. The data come from a wide array of sources, including government agencies, trade groups, international organizations, and the companies in the chemical and related industries. In many cases, these data have been treated to develop analytical measures and comparisons that add perspective to the industry's results.



at a glance

Section One: Production

Output in the U.S. chemical industry was up last year, but the growth rate eased as the year advanced and, for 1984 as a whole, gains were relatively moderate. Plastics had the best growth overall, with some of the lower-volume materials setting the pace. Among inorganic chemicals, fertilizer materials made a sharp recovery after two severely depressed years. On the other hand, man-made fibers, crimped by imports, had little or no growth.

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Section Two: Finance

Profits were higher for chemical producers in the U.S. By late 1984, however, growth had run out of steam. Consequently, profits remained well below levels of just four or five years ago. Basic chemical companies, however, are fattening their capital spending budgets, although with current capacity still more than adequate for products, outlays are still less than in the early 1980s. For R&D, conversely, budgets continue to grow steadily and this year will set a new high.

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Section Three: Employment

The workforce employed by the chemical industry expanded in 1984, but most of the growth took place during the first half and by year's end the number of employees was still far less than in 1981. Productivity of workers also was higher, but the gain was only a little better than a third of that made in 1983.

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Section Four: Foreign Trade

World trade in chemicals rose to an all-time high last year, increasing 14%. U.S. exports did nearly as well, recording a 13% increase. But imports of chemicals flooded into the U.S. as the dollar continued to strengthen. As a result, the nation's surplus in chemical trade was trimmed for the fourth year.

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Section Five: Foreign Chemical Industries

Continued growth was widespread among the world's chemical producers. Higher production and sales, moreover, fattened the previously depressed earnings of companies in Western Europe, Japan, and Canada. Even so, competition continued to be keen in world markets and excess capacity remains a problem that is still only partially resolved.

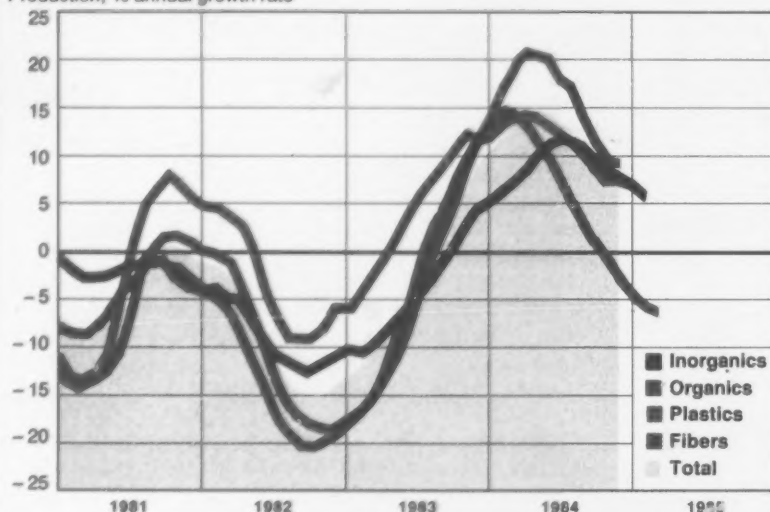
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1 Production by the U.S. Chemical Industry

Production increased only weakly in 1984

Chemical growth rate started to sag in 1984

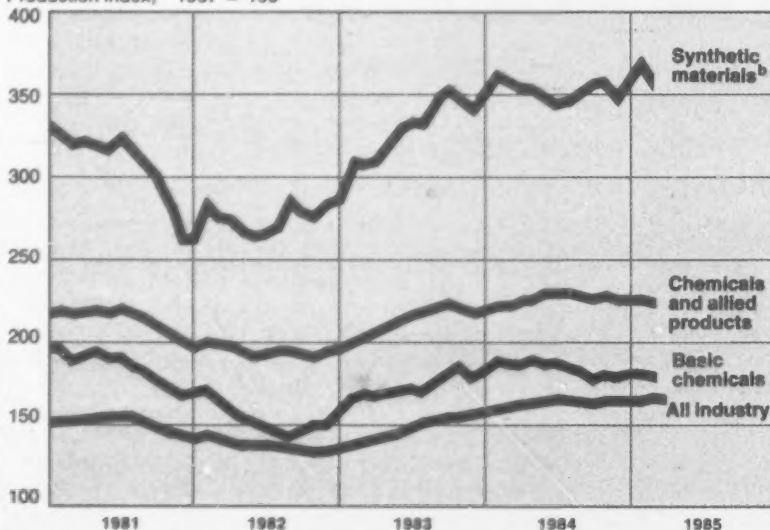
Production, % annual growth rate^a



^a Average running annual growth rates in production of major plastics, inorganic and organic chemicals, and all chemicals, and in shipments of man-made fibers. Sources: International Trade Commission, Bureau of the Census, Society of the Plastics Industry, Textile Economics Bureau

Chemical output hasn't grown significantly since late 1983

Production index,^a 1967 = 100



^a Seasonally adjusted. ^b Includes plastics, synthetic rubber, and man-made fibers. Source: Federal Reserve Board

Output of U.S. chemical plants increased 6% last year as compared with 1983. But although the chemical industry as a whole saw slow but steady growth in production at the beginning of 1984, the second half of the year and the early months of 1985 brought stagnation.

Plastic materials and synthetic rubber made the strongest gains of all the industry sectors in 1984, with plastics production rising to a new high for the second year in a row. Output of thermoplastic resins increased 15%, led by a 23% increase in nylon, and thermosetting resin production was up 6% overall. Synthetic rubber production also increased for the second year in a row, with output of nitrile and ethylene-propylene rubber growing more than 20%. Rubber output, however, is still below levels of a decade ago.

Among man-made fibers, only the output of rayon, olefins, and textile glass fibers rose in 1984. Production of the other major cellulose and noncellulose fibers either decreased or was unchanged from a year earlier. The strength of the U.S. dollar has undercut U.S. exports and opened U.S. markets to a rising flood of foreign-made fibers, textiles, and apparel.

Production of basic chemicals was up in every category in 1984, but grew only 6% overall and was still below 1981 levels. Acids and fertilizer materials showed the strongest growth, up 12% over the previous year. This reflects a 20% increase in fertilizer use in the U.S. last year, after two years of declining consumption.

Output of other chemical products increased 6%, the industry average for 1984. Production of agricultural chemicals, the only sector to decrease in output during 1983, grew 10% last year. Paint production was up 11%. Drugs, soaps, and toiletries expanded less than average.

TOP 50 CHEMICALS: Rise in output last year was well above average rate for the past decade

Rank			Billions of lb		Common units ^b		Average annual growth			
1984	1983 ^a		1984	1983	1984	1983	1983-84	1982-83	1978-84	1974-84
1	1	Sulfuric acid	79.37	73.17	39,683 tt	38,563 tt	8.5%	10.1%	-1.7%	1.6%
2	2	Nitrogen	43.41	40.56	599 bcf	560 bcf	7.0	15.9	7.0	9.4
3	6	Ammonia	32.41	28.14	16,204 tt	14,072 tt	15.2	-10.9	-2.8	0.3
4	3	Lime ^c	32.20	29.73	16,100 tt	14,867 tt	8.3	5.6	-5.1	-2.3
5	4	Ethylene	31.18	28.68	31,178 mp	28,677 mp	8.7	17.0	0.8	2.7
6	5	Oxygen	31.04	28.39	375 bcf	343 bcf	9.3	-1.7	-3.8	0.4
7	7	Sodium hydroxide	22.46	20.48	11,224 tt	10,230 tt	9.7	9.0	-2.6	0.0
8	9	Phosphoric acid	22.22	19.53	11,111 tt	9,767 tt	13.8	18.3	1.5	4.4
9	8	Chlorine	21.45	19.92	10,724 tt	9,960 tt	7.7	8.5	-2.6	0.0
10	10	Sodium carbonate ^d	17.02	16.93	8,511 tt	8,467 tt	0.5	8.3	0.6	1.2
11	12	Nitric acid	16.08	13.94	8,041 tt	6,968 tt	15.4	-5.7	-2.0	0.1
12	11	Propylene	15.47	13.96	15,470 mp	13,959 mp	10.8	11.4	1.7	4.0
13	14	Urea ^e	14.30	12.27	7,148 tt	6,137 tt	16.5	-5.1	0.4	6.9
14	13	Ammonium nitrate ^f	14.01	12.48	7,005 tt	6,240 tt	12.3	-12.0	-3.3	0.7
15	15	Ethylene dichloride	13.73	11.51	13,731 mp	11,506 mp	19.3	51.0	3.1	4.1
16	16	Benzene	9.86	9.08	1,339 mg	1,233 mg	8.6	17.2	-4.3	-1.0
17	18	Ethylbenzene	8.61	7.88	8,613 mp	7,876 mp	9.4	18.3	0.4	3.8
18	17	Methanol	8.28	7.98	8,280 mp	7,982 mp	3.7	5.7	2.4	1.9
19	19	Carbon dioxide ^g	7.80	7.76	3,898 tt	3,880 tt	0.5	1.6	5.5	8.0
20	21	Styrene	7.71	6.80	7,706 mp	6,802 mp	13.3	14.5	0.6	2.6
21	20	Vinyl chloride	7.51	6.88	7,513 mp	6,875 mp	9.3	40.2	3.3	2.9
22	26	Xylene	6.12	5.23	850 mg	726 mg	17.1	10.3	-2.6	0.6
23	23	Terephthalic acid ^h	6.05	5.63	6,047 mp	5,626 mp	7.5	16.2	0.4	3.6
24	24	Ethylene oxide	5.96	5.53	5,957 mp	5,534 mp	7.6	11.0	0.7	3.4
25	27	Hydrochloric acid	5.72	4.84	2,862 tt	2,420 tt	18.3	-1.2	-1.5	1.5
26	25	Formaldehyde ⁱ	5.71	5.47	5,712 mp	5,465 mp	4.5	13.5	-0.9	-0.1
27	22	Toluene ^j	5.27	5.66	726 mg	780 mg	-6.9	9.2	-6.4	-2.4
28	28	Ethylene glycol	4.84	4.43	4,842 mp	4,425 mp	9.4	2.7	0.5	3.8
29	29	p-Xylene	4.27	4.11	4,268 mp	4,114 mp	3.7	28.3	-1.7	4.7
30	30	Ammonium sulfate	4.13	3.91	2,063 tt	1,956 tt	5.5	10.6	-2.7	-0.3
31	32	Potash ^k	3.53	3.15	1,600 tmt	1,429 tmt	12.0	-19.9	-6.4	-4.6
32	31	Cumene	3.36	3.35	3,360 mp	3,345 mp	0.4	21.9	-3.0	1.5
33	35	Carbon black	2.89	2.50	2,893 mp	2,496 mp	15.9	8.4	-2.8	-1.5
34	34	Phenol ^l	2.85	2.64	2,845 mp	2,637 mp	7.9	30.4	-0.9	2.0
35	33	Acetic acid	2.84	2.81	2,842 mp	2,807 mp	-5.9	2.1	-4.1	0.2
36	36	Butadiene ^m	2.53	2.35	2,531 mp	2,353 mp	7.6	22.9	-6.7	-3.7
37	38	Acrylonitrile	2.20	2.15	2,201 mp	2,146 mp	2.6	5.5	1.8	4.5
38	37	Aluminum sulfate	2.16	2.21	1,079 tt	1,103 tt	-2.2	-4.3	-3.9	-1.5
39	44	Cyclohexane	2.13	1.66	2,130 mp	1,656 mp	28.6	29.9	-2.6	-1.0
40	42	Calcium chloride ⁿ	2.10	1.71	1,049 tt	857 tt	22.4	0.5	1.3	-0.5
41	39	Vinyl acetate	2.02	1.96	2,023 mp	1,963 mp	3.1	4.6	0.4	3.7
42	41	Propylene oxide	1.90	1.80	1,900 mp	1,800 mp	5.6	7.1	-3.3	0.8
43	40	Acetone	1.89	1.86	1,887 mp	1,859 mp	1.5	9.7	-6.6	-0.5
44	43	Sodium sulfate ^o	1.74	1.71	872 tt	854 tt	2.1	-1.2	-4.9	-4.3
45	45	Titanium dioxide	1.60	1.51	799 tt	757 tt	5.5	15.2	1.5	0.2
46	46	Sodium silicate	1.50	1.46	750 tt	728 tt	3.0	9.6	-1.6	-0.3
47	—	Methyl tert-butyl ether ^p	1.47	0.84	1,469 mp	839 mp	75.1	1.8	nm	nm
48	48	Adipic acid	1.39	1.28	1,390 mp	1,280 mp	8.6	10.6	-4.4	-0.6
49	47	Sodium tripolyphosphate	1.33	1.34	667 tt	669 tt	-0.3	2.8	-2.5	-3.0
50	49	Isopropyl alcohol	1.15	1.24	1,147 mp	1,209 mp	-5.1	-12.4	-9.6	-5.1
TOTAL ORGANICS			190.38	164.97			9.2%	13.5%	-0.4%	2.2%
TOTAL INORGANICS			366.15	335.36			8.4%	4.7%	-1.4%	1.1%
GRAND TOTAL			546.54	500.35			9.2%	7.4%	-1.1%	1.4%

a Revised. b tt = thousands of tons, bcf = billions of cubic feet, mp = millions of pounds, mg = millions of gallons, tmt = thousands of metric tons. c Except refractory dolomite. d Synthetic and natural. e 100% basis. f Original solution. g Liquid and solid only. h Includes both acid and ester without double counting. i 37% by weight. j All grades. k K₂O basis. l Synthetic only. m Rubber grade. n Solid and liquid. o High and low purity. p First year in which qualified for inclusion in Top 50; ethanol has been excluded. nm = not meaningful. Sources: Bureau of the Census, Bureau of Mines, International Trade Commission, O&E estimates

PRODUCTION: Chemical industry last year lagged manufacturing as a whole

Industrial production indexes, 1967 = 100	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Total index	163.3	147.6	138.6	151.0	147.0	152.5	146.1	138.2	130.5	117.8	129.3	11%	2%
Manufacturing, total	164.8	148.2	137.6	150.4	146.7	153.6	146.8	138.4	130.3	116.3	129.4	11	2
Nondurable manufacturing	179.4	168.1	156.2	164.8	161.2	164.0	156.9	150.5	141.8	126.4	134.6	7	3
Chemicals and products	228.1	215.0	196.1	215.6	207.1	211.8	197.4	185.7	170.9	147.2	159.4	6	4
Chemicals and synthetic materials	241.0	226.2	196.7	228.6	222.2	234.2	216.7	201.1	185.1	154.1	176.7	7	3
Basic chemicals	185.6	175.2	157.1	186.8	187.4	192.0	181.9	171.8	161.8	135.9	153.3	6	2
Alkalies and chlorine	116.9	108.5	99.2	114.7	121.4	132.3	119.7	119.2	119.0	106.5	125.6	8	-1
Gases, coal tar, inorganic pigments	192.0	177.4	160.0	181.5	184.3	197.7	186.0	174.3	164.4	133.3	165.0	8	2
Basic organic chemicals	229.7	220.9	192.9	236.7	231.6	233.3	221.2	204.7	189.8	155.3	177.9	4	3
Inorganic chemicals, nec	125.4	114.4	109.9	125.5	132.4	134.9	129.3	128.5	124.3	112.9	112.6	10	1
Acids and fertilizer materials	135.3	121.2	116.0	137.2	145.9	142.0	133.6	124.2	117.6	108.4	116.6	12	1
Synthetic materials	353.8	330.3	277.4	313.7	293.3	320.1	287.6	260.8	232.5	191.0	224.4	7	5
Plastics materials	539.4	486.0	403.6	429.3	386.5	420.1	366.5	320.3	280.1	213.1	258.5	11	8
Synthetic rubber	122.0	109.2	84.9	103.3	103.2	130.5	127.5	124.5	118.7	101.2	129.7	12	-1
Man-made fibers	234.5	236.2	204.2	254.4	250.3	270.8	250.9	236.8	214.3	191.2	214.4	-1	1
Chemical products	215.3	204.0	195.8	203.0	192.4	190.2	179.0	170.9	157.2	140.7	142.8	6	4
Drugs and medicines	295.0	280.6	266.8	267.1	245.7	238.2	220.6	213.9	191.5	174.1	179.6	5	5
Soap and toiletries	184.6	179.1	171.5	177.0	170.8	171.6	163.8	155.0	143.0	127.7	128.1	3	4
Paints	131.5	118.3	115.3	127.4	130.5	137.8	132.6	125.8	122.8	114.2	119.2	11	1
Agricultural chemicals	217.2	197.3	208.7	241.4	230.5	221.6	211.8	201.1	185.4	163.9	144.6	10	4
Petroleum products	124.4	120.3	121.8	129.7	132.9	143.9	145.2	142.6	133.5	124.1	124.7	3	0
Rubber and plastics products	331.7	291.9	254.7	274.0	255.7	272.2	253.6	232.3	199.7	166.7	195.2	14	5

nec = not elsewhere classified. Source: Federal Reserve Board

MINERALS: Production of most fertilizer raw materials still below 10 years ago

Thousands of tons	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Bromine, sold or used^a	170 ^b	185	200	189	189	249	223	217	230	204	216	-8%	-2%
Calcium chloride, production^{c,d}	1,049 ^b	912	853	917	811	981	1,031	968	897	828	1,101	15	0
Iodine, consumption^{e,f}	3.8 ^b	4.1	3.4	4.4	4.4	4.4	4.0	4.3	3.6	3.1	3.8	-6	0
Imports ^f	2.8 ^b	3.1	2.3	3.0	3.1	3.1	3.4	3.5	3.2	2.7	4.0	-11	-4
Lime, sold or used^g	16,100 ^b	14,867	14,075	18,890	19,037	20,983	20,484	19,987	20,257	19,159	21,645	8	-3
Lithium, consumption^{e,h}	2.6	2.2	2.0	3.2	3.0	3.2	3.4	4.1	2.8	2.9	3.8	18	-4
Phosphate rock													
Marketable production	54,230	46,928	41,241	59,110	59,982	58,891	55,156	52,091	49,231	48,806	45,676	16	2
Exports	12,707	13,239	10,849	11,458	15,737	15,827	14,187	14,584	10,398	12,270	13,895	-4	-1
Potash (K₂O equivalent)^j													
Production	1,764 ^b	1,575	1,967	2,377	2,468	2,453	2,484	2,457	2,400	2,501	2,552	12	-4
Imports ^j	5,401 ^b	4,894	4,253	5,287	5,481	5,693	5,189	5,076	4,594	3,797	4,325	10	2
Apparent consumption	6,724 ^b	6,231	5,647	6,849	6,999	7,626	6,840	6,605	6,149	5,113	6,086	8	1
Salt, total sold or used^k	37,750 ^b	34,573	37,880	38,915	40,396	45,820	42,896	43,439	44,218	41,057	46,565	9	-2
Evaporated ^l	5,285 ^b	5,532	5,303	6,209	6,358	6,248	5,872	5,704	5,634	5,372	5,951	-4	-1
Rock ^l	12,835 ^b	12,446	12,879	11,871	11,806	14,891	14,688	14,958	15,668	14,283	14,835	3	-1
Salt in brine ^l	19,630 ^b	16,595	19,698	20,835	22,231	24,681	22,336	22,777	22,917	21,401	25,779	18	-3
Sodium carbonate, productionⁿ	8,350 ^b	8,467	7,819	8,281	8,275	8,253	8,290	8,040	7,560	7,130	7,566	-1	1
Sulfur, production^m	11,742	10,240	10,788	13,388	13,080	13,339	12,318	11,824	11,992	12,610	12,789	15	-1
Apparent consumption ⁿ	13,976	12,112	11,088	14,093	15,056	15,145	13,889	12,850	12,060	11,875	12,115	15	1
Frasch, production	4,622	3,530	4,641	6,997	7,044	7,007	6,226	6,520	7,016	8,077	8,849	31	-6
Recovered elemental, production	5,747	5,462	4,855	4,695	4,490	4,486	4,478	3,995	3,514	3,326	2,948	5	7
Other, production	1,372	1,249	1,293	1,695	1,547	1,845	1,615	1,310	1,462	1,208	992	10	3

a Elemental bromine sold as such or used in preparation of bromine compounds by primary producers. b Preliminary figure. c 75% CaCl₂ equivalent. d Natural and synthetic. e Estimated apparent consumption. f Crude elemental iodine. g Includes Puerto Rican production. h Lithium content basis. i Includes muriate and sulfate of potash, potassium magnesium sulfate, and parent salts; excludes other chemical compounds containing potassium. j Includes nitrate of potash. k Total obtained by all recovery methods that was sold or used by domestic producers (figures differ slightly from U.S. production figures); figures for 1973-81 include Puerto Rican production. l Sold or used as such. m Sulfur content basis. n Calculated from shipments plus imports minus exports (sulfur content basis). Source: Bureau of Mines

ORGANIC CHEMICALS: Growth in output during past decade has been moderate at best

Millions of lb unless otherwise noted	Production											Annual change	
	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1983-84	1974-84
Acetic acid, synthetic	2,642	2,807	2,748	2,705	2,977	3,265	2,776	2,570	2,463	2,197	2,584	-6%	0%
Acetone	1,887	1,859	1,694	2,144	2,076	2,653	2,519	2,219	1,869	1,640	1,980	2	0
Acrylonitrile	2,201	2,146	2,035	1,997	1,830	2,018	1,752	1,646	1,518	1,215	1,412	3	5
Aniline	786	663	557	634	659	690	608	584	544	407	551	19	4
Benzene, mg ^{b,c}	1,339	1,232	1,052	1,308	1,534	1,612	1,435	1,371	1,365	959	1,406	9	0
Bisphenol A	762	643	480	555	530	576	471	455	449	293	370	19	7
1,3-Butadiene ^d	2,531	2,353	1,915	2,986	2,799	3,583	3,515	3,259	3,507	2,597	3,682	8	-4
1-Butanol	918	833	730	809	790	766	756	660	625	490	558	10	5
Caprolactam	1,027	977	793	928	905 ^e	945	919	867	780	713	668	5	4
Carbon tetrachloride	712	573	587	726	710	714	737	809	857	906	1,163	24	-5
Chloroform	393	362	299	405	273	356	349	302	292	262	302	9	3
Cumene	3,360	3,345	2,743	3,309	3,459	3,917	3,380	2,644	2,716	2,003	2,906	0	1
Cyclohexane	2,130	1,656	1,275	1,820	1,964	2,425	2,332	2,265	2,187	1,734	2,352	29	-1
Diethyl phthalate	292	300	266	304	353	336	409	400	413	312	395	-3	-3
Dodecylbenzene ^f	na	545	509	535	563 ^g	627	526	526	529	495	533	na	na
Ethanol, synthetic	1,108	1,077	1,023	1,317	1,451	1,408	1,267	1,339	1,496	1,429	1,618	3	-4
Ethanolamines ^h	514	468	416	429	376	420	362	308	286	258	307	10	5
Ethylbenzene	8,613	7,876	6,656	7,813	7,642	8,448	8,385	8,312	5,770	4,822	6,048	9	4
Ethyl chloride	292	282	339	324	396	582	540	612	669	575	662	4	-8
Ethylene	31,178	28,680	24,501	29,418	28,667	29,904	25,955	25,172	22,475	20,499	23,891	9	3
Ethylene dichloride	13,731	11,506	7,619	9,974	11,108	11,794	11,001	10,997	8,042	7,977	9,165 ^h	19	4
Ethylene glycol	4,842	4,425	4,309	4,143	4,386	4,729	3,904	3,675	3,335	3,809	3,341	9	4
Ethylene oxide	5,957	5,534	4,987	4,937	5,220	5,665	5,012	4,364	4,184	4,467	4,200 ⁱ	8	4
2-Ethylhexanol	512	387	325	389	367	318	420	493	450	387	395	32	3
Formaldehyde, 37% ^j	5,712	5,465	4,817	5,721	5,555	5,971	6,361	6,046	5,449	4,558	5,764	5	0
Isopropyl alcohol	1,147	1,209	1,380	1,669	1,836	1,900	1,730	1,888	1,936	1,521	1,939	-5	-5
Maleic anhydride	361	299	260	293	304	323	341	294	264	216	290	21	2
Methanol, synthetic	8,280	7,982	7,555	8,577	7,153	7,367	6,443	6,453	6,242	5,176	6,878	4	2
Methyl chloride	384	409	366	405	362	463	454	476	378	366	493 ^h	-6	-5
Methylchloroform	668	586	595	614	692	716	644	635	631	459	592	14	1
Methylene chloride	551	584	532	592	564	633	570	478	538	497	609	-6	-1
Methyl ethyl ketone	556	531	468	611	587	656	661	512	428	425	506	5	1
Methyl methacrylate	906	844	721	891	780	931	na	745	na	546	719	7	2
Perchloroethylene	509	547	585	691	765	773	725	614	669	679	734	-7	-4
Phenol, synthetic ^k	2,845	2,638	2,023	2,578	2,568	2,981	2,682	2,338	2,121	1,746	2,298	8	2
Phthalic anhydride	869	838	684	870	818	1,013	978	926	902	702	977	4	-1
Propylene ^l	15,470	13,959	12,535	13,482	13,676	14,198	13,014	13,328	10,030	8,709	10,475 ^m	11	4
Propylene glycol	487	484	400	473	488	610	547	489	517	391	510	1	-0
Styrene, monomer	7,706	6,802	5,942	6,679	6,856	7,484	7,186	6,867	6,301	4,673	5,956	13	3
Terephthalic acid, dimethyl ester ⁿ	6,047	5,626	4,843	6,235	6,054	6,159	5,954	5,410	5,051	4,614	4,262	7	4
Toluene, mg ^{b,o}	726	780	714	852	1,010	1,001	1,046	1,008	990	695	908	-7	-2
Vinyl acetate	2,023	1,963	1,876	1,936	1,922	1,982	1,692	1,586	1,481	1,290	1,403	3	4
Vinyl chloride	7,513	6,875	4,902	6,874	6,466	6,389	6,941	5,986	5,677	4,196	5,621	9	3
<i>o</i> -Xylene	696	781	802	918	995	1,082	1,013	985	854	703	1,056	-11	-4
<i>p</i> -Xylene	4,268	4,114	3,391	4,532	4,238	4,650	3,516	3,172	2,911	2,484	2,707	4	5

a Preliminary. b Tar distillers and coke-oven operators not included. c Specification grades. d Rubber grade. e Preliminary figure, final figure not available. f Includes straight-chain dodecylbenzene, tridecylbenzene, and other straight-chain alkylbenzenes. g Mono-, di-, and triethanolamines. h Production figure may be too low because some ethylene dichloride and methyl chloride were produced but not separated or measured accurately by some producers. i Approximate. j By weight. k Does not include data for coke ovens and gas-retort ovens. l All grades. m Includes data for propane-propylene mixture. n Includes both acid and dimethyl ester (DMT), without double counting. o High-purity toluene, includes material used in blending motor fuel. mg = millions of gallons. na = not available. Source: International Trade Commission

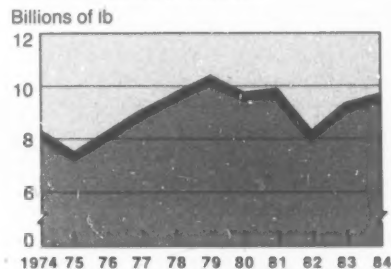
INORGANICS: Output of most chemicals up again in 1984 from 1982 trough

Thousands of tons unless otherwise noted	Production											Annual change	
	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1983-84	1974-84
Aluminum sulfate ^b	1,079	1,144	1,154	1,294	1,286	1,315	1,309	1,255	1,202	1,146	1,257	-6%	-2%
Ammonia, ^{c,d} 100%	16,204	14,072	15,801	19,044	19,653	18,634	17,119	17,765	16,716	16,419	15,733	15	0
Ammonium nitrate, ^e 100%	7,005	6,240	7,091	8,861	9,128	8,293	7,210	7,177	7,186	7,088	7,542	12	-1
Ammonium sulfate, ^{d,f} 100%	2,063	1,956	1,768	2,185	2,136	2,363	2,449	2,264	2,010	2,106	2,120	5	0
Chlorine gas ^g	10,724	9,960	9,176	10,763	11,421	12,291	11,052	10,573	10,378	9,167	10,753	8	0
Hydrochloric acid, ^h 100%	2,862	2,608	2,450	2,574	2,888	3,090	2,793	2,668	2,542	2,009	2,470	10	1
Hydrogen, ^{i,j} bcf, 100%	109	100	89	105	107	106	90	85	82	74	82	9	3
Nitric acid, ^k 100%	8,041	6,768	7,390	9,093	9,231	8,916	7,934	7,987	7,791	7,527	8,120	19	0
Nitrogen gas, ^{i,l} bcf, 100%	601	560	483	490	479	427	379	328	289	252	243	7	9
Oxygen, ^{i,l} bcf, 100%	375	343	349	431	431	456	430	392	388	353	390	9	0
Phosphoric acid, 100% P ₂ O ₅	11,111	9,767	8,253	9,958	10,848	10,318	9,637	8,745	7,949	7,677	7,213	14	4
Phosphorus ^m	384	366	361	426	432	460	441	430	437	450	524	5	-3
Sodium chlorate, 100%	245	310	291	297	312	269	265	251	199	173	203	-21	2
Sodium hydroxide, 100%	11,224	10,230	9,385	10,621	11,625	12,759	11,309	11,000	10,516	9,635	11,189	10	0
Sodium phosphate ⁿ	673	669	651	696	727	757	739	717	724	770	903	1	-3
Sodium silicate ^o	750	728	664	771	805	813	829	760	747	724	770	3	0
Sodium sulfate, ^p 100%	872	914	864	1,111	1,140	1,121	1,174	1,199	1,232	1,227	1,348	-5	-4
Sulfuric acid, ^q 100%	39,638	36,583	33,233	40,742	44,158	43,204	41,314	38,337	34,878	32,360	33,936	8	2
Titanium dioxide, ^r 100%	799	757	660	761	727	742	701	687	713	603	787	6	0
Urea	7,148	6,137	6,470	8,062	7,830	7,000	6,273	5,072	4,498	3,799	3,789	16	7

a Preliminary. b Commercial, 17% Al₂O₃; includes municipalities. c Synthetic anhydrous. d Excludes by-product ammonia liquor and ammonium sulfate. e Original solution. f Synthetic and noncoke by-product. g Includes quantities liquefied for use, storage, or shipment. h Includes anhydrous hydrochloric acid production. i High- and low-purity gas. j Liquid and gas; excludes amounts vented and used as fuel, and amounts produced in petroleum refineries for captive use. k Includes unspecified amounts of nitric acid produced but not withdrawn from the system. l Excludes amounts produced and consumed in making synthetic ammonia or ammonia derivatives. m Elemental, white (yellow), and red. n Triphosphate (100% Na₃P₃O₁₀). o Soluble silicate glass (water glass), solid and liquid (anhydrous); excludes amounts produced and consumed in making meta-, ortho-, and sesquisilicates. p Anhydrous, high and low purity, and Glauber's salt. q Gross (new and fortified). r Composite and pure. Note: bcf = billions of cubic feet. Sources: Department of Commerce, International Trade Commission

MAN-MADE FIBERS: Production edged higher last year

Man-made fibers production

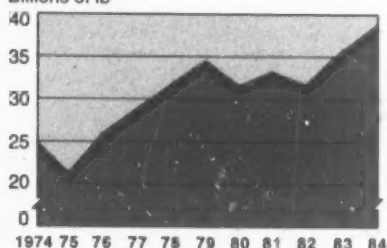


Millions of lb	Production											Annual change	
	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1983-84	1974-84
CELLULOSIC FIBERS													
Acetate ^a	199	229	196	261	316	324	308	290	298	313	382	-13%	-6%
Rayon	421	401	388	509	490	606	597	598	543	436	817	5	-6
NONCELLULOSIC FIBERS													
Acrylic ^b	671	671	624	691	779	761	726	709	621	525	631	0	1
Nylon	2412 ^c	2419 ^c	1927 ^d	2332 ^d	2358 ^d	2,720 ^d	2550 ^d	2326 ^d	2075 ^d	1857 ^d	2124 ^d	0	1
Olefin ^a	997	906	723	785	748	759	692	635	577	497	531	10	7
Polyester	3392	3544	3169	4176	3989	4,178	3800	3642	3340	2995	2926	-4	1
Textile glass	1394	1168	893	1041	867	1,014	923	787	676	546	683	19	7
TOTAL	9486	9336	7926	9795	9547	10,362	9596	8987	8130	7169	8094	2%	2%

a Includes diacetate and triacetate; excludes production for cigarette filters. b Includes modacrylic. c Excludes aramid. d Includes aramid. e Includes olefin yarn and monofilaments and olefin and vinyon staple and tow. Note: Totals may not add because of rounding. Source: Textile Economics Bureau

Plastics production

Billions of lb



PLASTICS:
Output hit a new
high for the second
year in a row

Millions of lb ^a	Production											Annual change	
	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1983-84	1974-84
THERMOSETTING RESINS													
Epoxy ^b	406	334	286	336	315	361	299	261	244	198	249	22%	5%
Polyester ^c	1,232	1,084	865	997	947	1,147	1,209	1,061	1,042	834	911	14	3
Urea	1,199	1,172	998	1,165	1,165	1,367	1,122	963	821	690	835	2	4
Melamine	210	180	158	179	167	200	202	200	186	115	164	17	3
Phenolic ^d	2,502 ^e	2,477 ^e	2,006 ^e	2,333 ^e	1,499	1,781	1,617	1,458	1,340	1,051	1,335	1	nc
TOTAL	5,549	5,247	4,313	5,010	4,093	4,856	4,449	3,943	3,633	2,888	3,494	6%	nc
THERMOPLASTIC RESINS													
Polyethylene													
Low density ^f	8,413	8,041	7,503	7,693	7,291	7,793	7,111	6,471	5,813	4,743	5,973	5	3
High density ^g	6,085	5,689	4,928	4,695	4,405	5,010	4,201	3,652	3,125	2,468	2,837	7	8
Polypropylene	4,940	4,433	3,477	3,955	3,648	3,841	3,074	2,747	2,632	1,902	2,249	11	8
Styrene-acrylonitrile	99	93	91	107	111	124	120	115	113	109	109	6	-1
Polystyrene	3,838	3,570	3,191	3,621	3,521	4,005	3,823	3,446	3,195	2,662	3,364	8	1
Styrene-butadiene copolymers, acrylonitrile-butadiene-styrene, and other styrene polymers	2,127	1,889	1,380	1,745	1,705	2,107	2,012	1,882	1,744	1,227	1,536	13	3
Polyamide, nylon type	396	321	228	312	274	327	275	254	247	135	204	23	7
Polyvinyl chloride and copolymers	6,760	6,067	5,326	5,707	5,470	6,119	5,723	5,253	4,716	3,648	4,850	11	3
Other vinyl resins ^h	187	186	177	208	196	220	197	197	225	187	209	1	-1
TOTAL	32,845	30,289	26,301	28,043	26,621	29,546	26,536	24,017	21,810	17,081	21,331	15%	4%

^a Dry-weight basis, unless otherwise specified. ^b Unmodified. ^c Unsaturated. ^d Includes other tar acid resins. ^e Gross-weight basis. ^f 0.940 density and below. ^g Density above 0.940. ^h Includes polyvinyl butyral, polyvinyl formal, and polyvinylidene chloride. nc = not comparable. Source: Society of the Plastics Industry

SYNTHETIC RUBBER: Volume rose in all categories in 1984

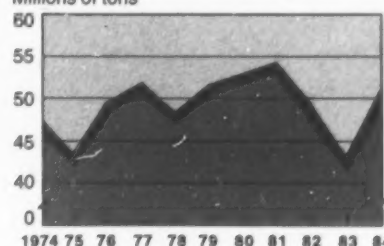
Thousands of metric tons	Production											Annual change	
	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1983-84	1974-84
Styrene-butadiene rubber ^a	958	904	876	1032	1074	1378	1395	1395	1333	1179	1466	6%	-4%
Polybutadiene	359	333	288	342	311	397	378	361	352	290	310	8	1
Nitrile	67	55	45	66	63	75	73	70	73	55	88	22	-3
Ethylene-propylene	215	175	123	178	144	175	174	158	130	84	126	23	5
Polychloroprene	130	115	119	143	151	183	161	165	165	144	163	13	-2
Other ^b	365 ^c	353 ^c	379 ^c	261	272	326	292	267	250	188	345	3	1
TOTAL	2094	1935	1830	2022	2015	2534	2473	2416	2303	1940	2498	8%	-2%

^a Excludes high-styrene latex (more than 45% styrene). ^b Includes butyl, polyisoprene, silicone, and other synthetic elastomers. Excludes polyurethane rubber. ^c Values are partly estimated. Source: Rubber Manufacturers Association

FERTILIZERS: U.S. production rose for phosphates and nitrogen but not potash

Fertilizer consumption

Millions of tons



Note: Years ending June 30.
Source: Department of Agriculture

Thousands of tons	Production										Annual change		
	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1983-84	1974-84
NITROGEN (N)													
Domestic production	10,364	9,855	11,598	13,036	12,323	11,106	10,466	10,789	10,572	9343	10,094	5%	0%
Imports	3,940	2,654	2,531	2,455	2,566	2,165	1,866	1,842	1,218	1198	1,068	48	14
Exports	2,080	2,074	2,499	3,088	2,641	2,468	1,778	1,251	1,239	1115	1,269	0	5
Domestic supply	12,224	10,435	11,630	12,403	12,248	10,803	10,554	11,380	10,551	9426	9,893	17	2
PHOSPHATE (P ₂ O ₅)													
Domestic production	9,611	8,043	7,818	10,471	10,012	9,432	8,245	7,793	7,199	7230	6,869	19	3
Imports	121	133	193	250	239	236	229	245	221	274	315	-9	-9
Exports	4,352	3,916	3,751	4,381	3,925	3,848	3,290	2,501	2,175	1860	1,581	11	11
Domestic supply	5,380	4,260	4,260	6,340	6,326	5,820	5,184	5,537	5,245	5644	5,603	26	0
POTASH (K ₂ O)													
Domestic production	1,653	1,859	1,831	2,262	2,474	2,519	2,176	2,584	2,313	2287	2,604	-11	-4
Imports	5,164	4,402	4,797	5,487	5,403	5,085	4,948	4,955	3,910	3847	4,114	17	2
Exports	528	624	641	876	1,048	999	1,003	994	911	848	947	-15	-6
Domestic supply	6,289	5,637	5,987	6,873	6,829	6,605	6,121	6,545	5,312	5286	5,771	12	1

Note: Years ending June 30. Source: Department of Agriculture

After two poor years, U.S. fertilizer use increased 20% last year

Millions of tons	Consumption										Annual change		
	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1983-84	1974-84
TYPE													
Mixed fertilizer ^a	21.2	18.4	20.9	23.5	23.3	23.7	22.1	24.1	23.0	20.6	24.1	15%	-1%
Primary nutrient material ^b	29.0	23.5	27.8	30.5	29.5	27.7	25.4	27.5	26.2	21.8	23.0	23	2
TOTAL	50.2	41.9	48.7	54.0	52.8	51.4	47.5	51.6	49.2	42.4	47.1	20%	1%
PRIMARY NUTRIENT CONTENT													
Nitrogen (N)	11.0	9.1	11.0	11.9	11.4	10.7	10.0	10.6	10.4	8.6	9.2	22	2
Phosphate (P ₂ O ₅)	4.9	4.1	4.8	5.4	5.4	5.6	5.1	5.6	5.2	4.5	5.1	19	0
Potash (K ₂ O)	5.8	4.8	5.6	6.3	6.2	6.2	5.5	5.8	5.2	4.5	5.1	20	1
TOTAL	21.9	18.1	21.4	23.7	23.1	22.6	20.6	22.1	20.9	17.6	19.3	21%	1%

^a Fertilizer materials that contain more than one primary nutrient. ^b Fertilizer materials that contain one primary nutrient. Note: Years ending June 30. Source: Department of Agriculture

NITROGEN OUTPUT: Up, but still below 1982

Thousands of tons (N)	1984	1983	1982	1974	Change 1983-84
Ammonia ^a	4,179	3,587	5,032	4,370	17%
Ammonium nitrate ^{b,c}	913	943	1,105	1,317	-3
Urea	1,786	1,692	1,684	586	6
Ammonium sulfate ^c	517	395	432	562	31
All other	2,969	3,238	3,345	3,306	-8
TOTAL	10,364	9,855	11,598	10,141	5%

^a Includes aqueous solutions. ^b Includes ammonium nitrate-limestone mixtures. ^c Adjusted for estimated quantity going into nonfertilizer uses. Note: Years ending June 30. Source: Department of Agriculture

PHOSPHATE OUTPUT: Another strong year

Thousands of tons (P ₂ O ₅)	1984	1983	1982	1974	Change 1983-84
Ammonium phosphate ^a	6,156	5,026	4,434	2,664	22%
Concentrated superphosphate	1,172	1,184	1,151	1,714	-1
Normal and enriched superphosphate	113	110	153	673	3
All other	2,170	1,723	2,080	1,539	26
TOTAL	9,611	8,043	7,818	6,590	19%

^a Liquid and solid, excluding that combined with potash salts in process of manufacture. Note: Years ending June 30. Source: Department of Agriculture

Production by the U.S. Chemical Industry 1

ENERGY USE BY CHEMICAL INDUSTRY: Natural gas's share continues to decline

Energy source ^a	1984		1983		1982		1981		1972		Change 1972-84	
	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	%
Natural gas	1005	36.5%	1010	37.6%	1051	38.7%	1272	40.2%	1537	47.4%	-532	-34.6%
Purchased electricity ^b	819	29.8	814	30.3	811	29.9	931	29.4	729	22.5	90	12.3
Petroleum-based fuels	541	19.7	458	17.1	472	17.4	542	17.1	564	17.4	-23	-4.0
Light hydrocarbons ^c	330	12.0	308	11.4	325	12.0	351	11.1	309	9.5	22	7.0
Residual fuels	65	2.4	91	3.4	88	3.2	104	3.3	162	5.0	-97	-60.0
Distillate fuels	13	0.5	12	0.4	14	0.5	18	0.6	34	1.0	-21	-61.6
Other fuel ^d	133	4.8	48	1.8	45	1.7	70	2.2	59	1.8	74	123.9
Coal and coke	295	10.7	320	11.9	295	10.9	324	10.2	282	8.7	13	4.8
Purchased steam	91	3.3	85	3.2	83	3.1	98	3.1	128	4.0	-37	-28.7
TOTAL	2752	100.0%	2688	100.1%	2712	100.0%	3167	100.0%	3240	100.0%	-488	-15.1%

^a For energy and process use only, excluding energy equivalent of feedstock. ^b Electricity is calculated as fuel value of 10,000 Btu to generate 1 kWh instead of using standard conversion factor of 3412 Btu per kWh. ^c Includes propane, liquefied petroleum gas, and other gases. ^d Includes petroleum coke, gasoline, and other liquids and solids. **Note:** Data from companies accounting for about 90% of U.S. capacity for basic industrial chemicals. **Source:** Chemical Manufacturers Association

ENERGY USE BY FERTILIZER INDUSTRY: Total rises sharply but is still below earlier peak

Energy source ^a	1984		1983		1982		1981		1972		Change ^b 1972-84	
	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	%
Natural gas	160.0	78.3%	125.6	77.6%	151.8	76.8%	200.6	81.2%	161.3	79.3%	-1.3	-0.8%
Purchased electricity ^c	38.7	18.9	31.9	19.7	33.7	17.1	43.7	17.7	35.3	17.4	3.4	9.7
Petroleum-based fuels	2.8	1.4	0.4	0.3	4.4	2.3	1.8	0.7	6.2	3.1	-3.5	-55.4
Residual fuels	2.2	1.1	0.4	0.2	4.4	2.2	1.0	0.4	3.8	1.9	-1.7	-43.3
Distillate fuels	na	na	na	na	na	na	0.7	0.3	2.2	1.1	na	na
Other fuel ^d	0.6	0.3	0.1	0.1	0	0	0.2	0.1	0.2	0.1	0.4	244.5
Coal and coke	na	na	na	na	na	na	0.5	0.2	0.5	0.2	na	na
Generated steam ^e	2.8	1.4	3.9	2.4	7.6	3.8	na	na	na	na	na	na
Purchased steam	0	0	0	0	0	0	0.4	0.1	0.1	0	-0.1	100
TOTAL	204.3	100.0%	161.8	100.0%	197.6	100.0%	246.9	99.9%	203.3	100.0%	0.9	0.5%

^a For energy and process use only, excluding energy equivalent of feedstock. ^b Data for 1984 cover 21 firms, but one firm is not included in 1972 base owing to unavailability of data because of corporate realignment. ^c Electricity is calculated as fuel value of 10,000 Btu to generate 1 kWh instead of using standard conversion factor of 3412 Btu per kWh. ^d Includes propane, liquefied petroleum gas, gasoline, diesel oil, kerosene, and other fuels. ^e Steam generated from fossil fuel, listed prior to 1982 under residual fuels, distillate fuels, other fuel, and coal and coke. **na** = not available. **Note:** Data from companies accounting for more than 70% of U.S. ammonia capacity. **Source:** Fertilizer Institute

ENERGY USE BY PETROLEUM INDUSTRY: Little change last year

Energy source ^a	1984		1983		1982		1981		1972		Change 1972-84	
	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	%
Natural gas	589	23.0%	565	22.3%	591	22.4%	686	24.7%	970	33.7%	-381	-39.3%
Purchased electricity ^b	246	9.6	244	9.6	242	9.1	250	9.0	190	6.6	56	29.3
Petroleum-based fuels	1695	66.2	1696	66.9	1781	67.5	1810	65.1	1678	58.3	17	1.0
Light hydrocarbons ^c	1123	43.8	1118	44.1	1189	45.0	1194	43.0	996	34.6	126	12.7
Residual fuels	125	4.9	134	5.3	149	5.6	177	6.4	243	8.5	-119	-48.7
Petroleum coke	438	17.1	433	17.1	429	16.2	428	15.4	417	14.5	22	5.2
Other fuel ^d	9	0.3	11	0.4	15	0.5	11	0.4	21	0.7	-12	-58.0
Coal and coke	6	0.2	7	0.3	6	0.2	5	0.2	5	0.2	1	15.7
Purchased steam	25	1.0	23	0.9	20	0.8	28	1.0	35	1.2	-10	-28.3
TOTAL	2561	100.0%	2534	100.0%	2640	100.0%	2779	100.0%	2878	100.0%	-318	-11.0

^a For energy and process use only, excluding energy equivalent of feedstock. ^b Electricity is calculated as fuel value of 10,000 Btu to generate 1 kWh instead of using standard conversion factor of 3412 Btu per kWh. ^c Includes propane, liquefied petroleum gas, and refinery gas. ^d Includes distillate fuels, gasoline, and other liquids. **Note:** Data from companies accounting for about 85% of U.S. petroleum refining capacity, including Puerto Rico. **Source:** American Petroleum Institute

Sales, earnings, profitability up in 1984

Compared with the previous couple of years, 1984 was a good year for the chemical industry. Combined sales for C&EN's 30-company sample increased 7% to \$73.4 billion, following a 6% increase in 1983. Earnings last year were up 27% to \$3.8 billion, after an 11% increase the year before.

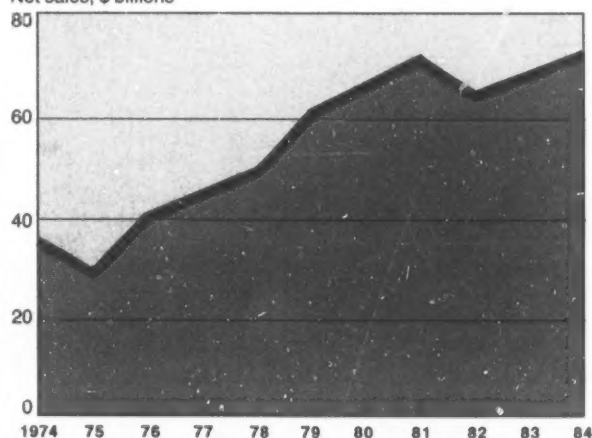
The result was that in 1984, chemical company profitability was up well above that in 1983 and 1982. Profit margins (earnings as a percentage of sales) for the 30 companies averaged 5.2%, compared with 4.4% in 1983. Average return on equity (earnings as a percentage of

year's end stockholders' equity) climbed to 11.4% in 1984 from 8.9% the year before.

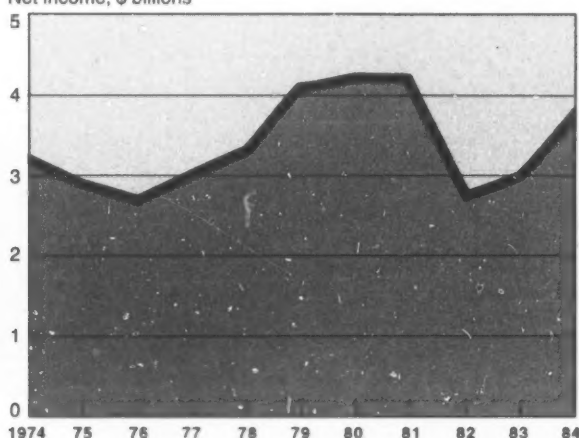
However, despite the good performance last year, the chemical industry still has a long way to go to recover its former luster. Although sales for the 30 companies climbed above their earlier high of \$72.2 billion reached in 1979, earnings still are considerably below their previous record of \$4.2 billion set in 1980 and 1981. And profitability, although up well in 1984 from the year before, still is nowhere near the levels reached in the late 1970s.

Chemical companies' sales set a record in 1984, but earnings were below their earlier high and profitability remained under previous levels

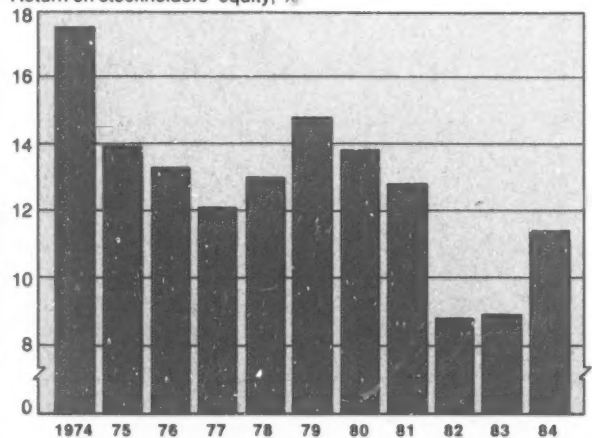
Net sales, \$ billions



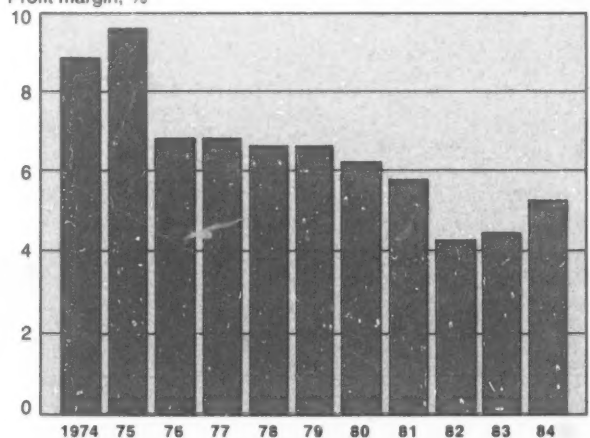
Net income, \$ billions



Return on stockholders' equity, %^a



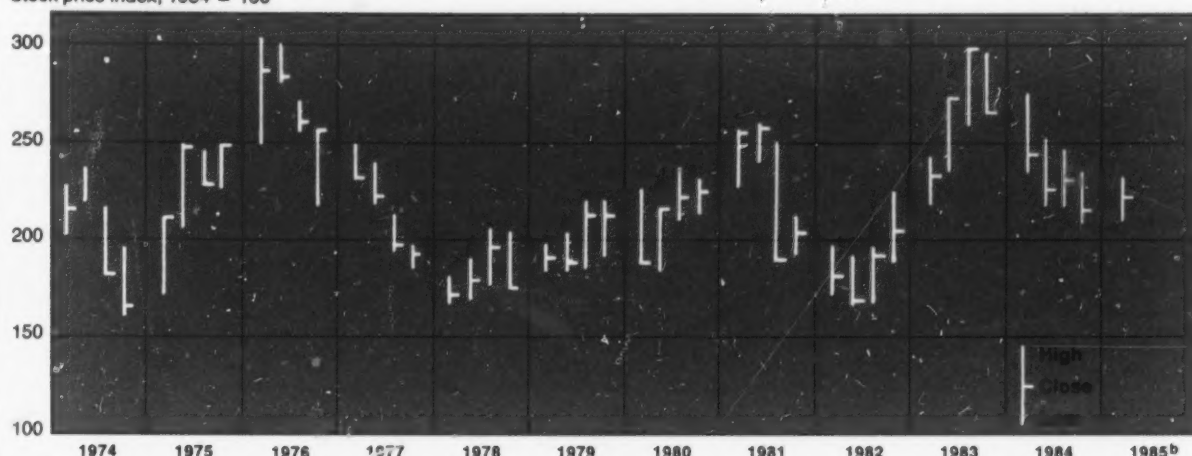
Profit margin, %^b



^a After-tax earnings as a percentage of year-end stockholders' equity. ^b After-tax earnings as a percentage of sales. Note: Data based on annual figures for 30 major chemical companies.

Chemical stock prices have slumped since late 1983

Stock price index, 1954 = 100^a



^a C&EN weighted stock price index of Allied Corp., American Cyanamid, Celanese, Dow Chemical, W. R. Grace, Monsanto, and Union Carbide; weighted according to number of shares outstanding for each company. ^b First quarter.

SHIPMENTS: A second year of healthy growth for chemical industry sales

\$ Billions	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
All manufacturing industries	\$2273.3	\$2047.4	\$1910.1	\$1994.6	\$1851.0	\$1727.2	\$1523.4	\$1358.4	\$1185.6	\$1039.1	\$1017.5	11%	8%
Chemicals and allied products	211.3	190.2	172.8	175.1	161.6	147.7	129.8	118.2	104.1	89.7	83.7	11	10
Industrial chemicals ^b	68.7	59.1	55.8	60.7	56.4	52.3	44.8	41.5	35.6	29.4	26.6	16	10
Drugs, soap, and toiletries	53.6	50.4	48.6	44.1	41.9	36.7	34.7	30.6	27.8	24.3	22.2	6	9
Petroleum and coal products	197.9	191.6	206.4	220.3	198.7	148.4	103.9	97.5	82.3	69.5	58.9	3	13
Rubber and plastic products, nec	52.2	50.3	50.2	46.5	47.3	46.8	43.2	39.6	31.8	27.2	27.9	4	6
Paper and allied products	95.9	85.1	79.0	79.5	72.6	65.2	57.0	52.1	48.2	41.7	41.8	13	9

^a Preliminary. ^b Excluding pigments. nec = not elsewhere classified. Source: Department of Commerce

PRICES: Only small increases in most of chemical industry

Producer price indexes, ^a 1967 = 100	Annual average											Annual change	
	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1983-84	1974-84
All commodities	310.3	303.1	299.3	293.4	268.8	235.6	209.3	194.2	183.0	174.9	160.1	2%	7%
Industrial commodities	322.6	315.8	312.3	304.1	274.8	236.5	209.4	195.1	182.4	171.5	153.8	2	8
Chemicals and allied products	300.9	292.9	292.4	287.6	260.3	222.3	198.8	192.8	187.2	181.3	146.8	3	7
Industrial chemicals	341.4	342.9	353.0	363.3	324.0	264.0	225.6	223.9	219.3	206.9	151.7	0	8
Prepared paint	272.5	264.7	262.9	249.8	235.3	204.4	192.3	182.4	174.4	166.9	145.7	3	6
Paint materials	329.5	305.6	304.6	300.1	273.9	241.2	212.7	205.9	189.8	177.2	152.3	8	8
Drugs and pharmaceuticals	240.4	226.2	210.1	193.5	174.5	159.4	148.1	140.5	134.0	126.6	112.7	6	8
Fats and oils, inedible	371.3	283.7	267.1	295.6	298.0	376.7	315.8	279.0	249.9	255.2	338.2	31	1
Agricultural chemicals and chemical products	284.7	280.7	292.7	285.0	257.1	214.4	198.4	187.8	188.4	203.6	137.7	1	8
Plastic resins and materials	308.6	290.2	283.3	289.2	279.2	235.9	199.8	195.7	194.0	180.9	143.8	6	8
Other chemicals and allied products	277.3	273.7	269.8	254.2	224.5	191.8	181.8	175.7	170.7	168.6	147.5	1	7
Rubber and plastics products	247.2	243.4	241.6	232.6	217.4	194.3	174.8	167.6	159.2	150.2	136.2	2	6

^a Formerly called "wholesale price indexes." Source: Department of Labor

TOP 100 CHEMICAL PRODUCERS: Only a third get more than 75% of their total sales volume from

Rank 1984 ^a 1983	Company	Chemical sales 1984 (\$ millions)	Change from 1983	Chemical sales as % of total sales	Industry classification	Chemical operating profits ^b (\$ millions)	Change from 1983	Chemical operating profits as % of total operating profits ^c	Operating profit margin ^d	Identifi- fiable chemical assets (\$ millions)	Chemical assets as % of total assets	Operating return on chemical assets ^e
1 1	Du Pont	\$12,005	3.4%	33.4%	Diversified	\$1107	-3.2%	25.4%	9.2%	\$7538	34.3%	14.7%
2 2	Dow Chemical	9,591	8.1	84.0	Basic chemicals	741	29.3	87.4	7.7	7645	86.9	9.7
3 3	Exxon	6,870	7.5	7.2	Petroleum	677	80.1	6.5	9.9	5246	8.3	12.9
4 4	Monsanto	5,951 ^a	7.6	88.9	Basic chemicals	669	35.7	98.8	11.2	5054	79.3	13.2
5 5	Union Carbide	4,158	6.3	43.7	Basic chemicals	480	74.5	49.3	11.5	4683	46.4	10.2
6 7	Shell Oil	3,383	4.8	16.3	Petroleum	273	110.0	8.5	8.1	3624	15.3	7.5
7 6	Celanese	3,326	2.1	100.0	Basic chemicals	272	27.1	100.0	8.2	3104	100.0	8.8
8 10	Atlantic Richfield	3,144	23.3	12.8	Petroleum	148	131.3	3.9	4.7	2616	11.8	5.7
9 9	W. R. Grace	2,848	3.2	42.3	Specialty chemicals	336	3.7	57.7	11.8	1779	36.3	18.9
10 8	Amoco Corp.	2,834	-2.5	9.7	Petroleum	349	101.7	8.2	12.3	2249	9.6	15.5
11 12	Mobil	2,607	11.8	4.3	Petroleum	56	def	1.1	2.1	2253	5.7	2.5
12 13	Eastman Kodak	2,464	7.8	22.7	Photo equipment	281	31.3	18.2	11.4	2054	19.1	13.7
13 11	Allied	2,433	4.1	22.7	Diversified	231	3.1	17.2	9.5	1345	16.4	17.2
14 14	Phillips Petroleum	2,351	4.3	15.1	Petroleum	221	166.3	8.9	9.4	1498	8.8	14.8
15 —	General Electric	2,117	7.8	7.3	Electrical products	470	42.9	12.1	22.2	2362	9.6	19.9
16 16	Rohm & Haas	962	8.5	96.1	Basic chemicals	333	11.7	103.4	17.0	1293	95.2	25.8
17 18	American Cyanamid	1,898	10.4	49.2	Basic chemical	135	27.0	38.4	7.1	1273	53.7	10.6
18 15	Hercules	1,823	-9.2	70.9	Basic chemicals	129	6.6	61.4	7.1	1335	78.9	9.7
19 20	Air Products ^f	1,604	13.7	92.5	Basic chemicals	292	49.2	107.1	18.2	1731	74.3	16.9
20 25	Ciba-Geigy	1,560	21.0	66.1	Specialty chemicals	na	na	na	0.0	na	na	na
21 29	Texaco	1,538	35.3	3.2	Petroleum	39	def	1.0	2.5	1008	3.0	3.9
22 21	Stauffer Chemical ^g	1,504	12.2	100.0	Basic chemicals	129	def	100.0	8.6	1601	100.0	8.1
23 27	Ashland Oil	1,501	24.3	16.8	Petroleum	55	5400.0	21.8	3.7	503	14.6	10.9
24 22	Mobay	1,500	15.4	100.0	Basic chemicals	135 ^h	103.9	100.0	9.0	na	na	na
25 20	American Hoechst	1,468 ^a	20.1	83.4	Basic chemicals	na	na	na	0.0	na	na	na
26 24	Borden	1,448	11.8	31.7	Dairy products	170	23.5	41.2	11.7	1340	48.6	12.7
27 30	B. F. Goodrich	1,424	25.7	43.5	Rubber products	114	157.8	68.6	8.0	1366	56.5	8.4
28 32	U.S. Steel	1,365	21.0	7.1	Steel	57	def	3.6	4.2	613	3.5	9.3
28 19	Ethyl	1,365 ^a	-7.7	81.5	Basic chemicals	190	21.6	85.2	13.9	790	80.8	24.0
30 31	Unocal Corp.	1,249	10.3	10.8	Petroleum	87 ^h	18.1	12.5	7.0	747	7.3	11.7
31 23	FMC	1,236	-4.7	37.0	Machinery	187	10.6	47.5	15.1	985	53.4	19.0
32 35	BASF Wyandotte	1,185	14.6	100.0	Basic chemicals	34	72.2	100.0	2.9	na	na	na
33 33	Olin	1,174	5.6	56.8	Basic chemicals	61	-10.6	35.1	5.2	1021	62.9	5.9
34 34	Standard Oil of Calif.	1,100	3.9	4.0	Petroleum	11 ^h	def	0.7	1.0	847	4.2	1.3
35 42	National Distillers	1,061	37.6	48.1	Alcoholic beverages	102	49.9	56.0	9.4	763	40.4	13.3
36 38	PPG Industries	993	12.6	23.4	Glass products	122	63.1	20.9	12.3	1150	35.8	10.6
37 28	Occidental Petroleum	985 ^h	-13.4	6.1	Petroleum	69	def	4.2	7.0	991	8.1	6.9
38 36	International Minerals ⁱ	977	-1.9	62.3	Agrochemicals	146	-6.6	63.0	14.9	1323	67.3	11.0
39 40	Borg-Warner	944	14.3	24.1	Auto equipment	121	10.1	31.3	12.8	376	20.3	32.3
40 39	CF Industries	908 ^a	5.3	100.0	Agrochemicals	54	58.4	100.0	6.0	1014	100.0	5.4
41 57	Koppers	885	8.2	48.7	Diversified	18	-15.4	22.9	2.0	466	43.3	3.8
42 43	Dow Corning	855	12.0	100.0	Specialty chemicals	91 ^g	33.0	100.0	10.6	na	na	na
43 41	Lubrizol	832	5.3	100.0	Specialty chemicals	102	3.7	100.0	12.3	702	100.0	14.6
44 45	Williams Cos.	831	12.3	24.5	Agrochemicals	66	9628.6	17.7	8.2	932	20.6	7.3
45 37	Diamond Shamrock	820	-12.9	18.3	Petroleum	116	869.2	22.9	14.2	764	14.2	15.2
46 44	Reichhold Chemicals	801	7.2	100.0	Basic chemicals	44	26.1	100.0	5.4	361	100.0	12.1
47 58	Farmland Industries	783	44.5	14.9	Agricultural supplies	32	def	27.6	4.1	447	37.0	7.1
48 46	Eli Lilly	757	4.1	24.3	Drugs	108	10.0	13.2	14.2	773	21.2	13.9
49 48	Badische	709	5.6	100.0	Basic chemicals	33	11.2	100.0	4.8	518	100.0	6.3
50 56	Standard Oil (Ohio)	707	24.9	5.8	Petroleum	44	def	1.5	6.2	664	3.8	6.6

a Revised. b Operating profit defined as sales less administrative expense and cost of sales. c Operating profit from chemicals as a percentage of total operating profits. d Operating profit as a percentage of identifiable chemical assets. e Chemical sales include significant amounts of nonchemical products. f Fiscal year ended Sept. 30. g Chemical net profits. h Does not include

chemical operations

Rank 1984 ^a 1993	Company	Chemical sales 1984 (\$ millions)	Change from 1993	Chemical sales as % of total sales	Industry classification	Chemical operating profits ^b (\$ millions)	Change from 1993	Chemical operating profits as % of total operating profits ^a	Operating profit margin ^c	Identifi- fiable chemical assets (\$ millions)	Chemical assets as % of total assets	Operating return on chemical assets ^d
51 52	Unroyal	672	13.3	31.7	Rubber products	\$110	89.0%	47.5%	16.4%	\$443	39.0%	24.9%
52 49	Nalco Chemical	664	0.7	100.0	Specialty chemicals	115	-2.0	100.0	17.3	479	100.0	24.0
53 51	Pennwalt	656	8.3	62.6	Basic chemicals	52	19.8	66.4	7.9	506	69.9	10.2
54 65	Morton Thiokol	654	45.9	32.7	Diversified	81	72.0	35.2	12.4	497	43.0	16.3
55 50	Merck	642	6.0	18.0	Drugs	73	49.3	9.7	12.2	596	16.9	13.1
56 55	Witco Chemical	623	9.0	41.6	Specialty chemicals	65	20.7	41.7	10.5	271	35.2	24.1
57 59	National Starch	561	10.5	66.6	Specialty chemicals	na	na	na	0.0	na	na	na
58 82	Engelhard	560	-1.1	22.3	Specialty metals	66	-7.9	58.7	11.8	442	51.2	14.9
59 63	Cabot	542	17.8	30.9	Specialty metals	67	53.9	31.8	12.4	291	16.1	24.0
60 67	Kerr-McGee	520	16.5	14.7	Petroleum	-25	def	def	def	580	16.0	def
61 66	Freeport-McMoran	493	11.9	58.6	Agrochemicals	110	47.8	87.3	22.2	220	11.5	49.8
62 62	International Flavors	477	3.4	100.0	Specialty chemicals	116	4.6	100.0	24.3	368	100.0	31.5
63 80	NL Industries	473	0.6	34.7	Petroleum services	95	50.6	91.1	20.1	283	21.6	33.5
64 68	Polymer	464	6.6	100.0	Basic chemicals	na	na	na	0.0	na	na	na
65 69	H. B. Fuller	447	4.9	100.0	Specialty chemicals	32	-3.4	100.0	7.2	226	100.0	14.2
66 47	Georgia-Pacific	446	-34.7	6.3	Wood products	-134	def	def	def	158	3.3	def
67 70	Henkel	430	7.5	100.0	Specialty chemicals	na	na	na	0.0	na	na	na
68 72	Liquid Air	426	9.3	84.9	Basic chemicals	52	6.6	96.3	12.2	na	na	na
69 61	Sun Co.	422	-9.6	2.7	Petroleum	na	na	na	0.0	na	na	na
70 73	InterNorth	396	5.7	5.3	Natural gas	47	76.8	8.1	11.9	636	10.8	7.4
71 71	Pfizer	377	-4.4	9.8	Drugs	5	-10.0	0.5	1.2	382	9.4	1.2
72 90	Terra Chemicals	370	30.7	100.0	Agrochemicals	na	na	na	0.0	na	na	na
72 81	Rhône-Poulenc	370	27.6	100.0	Specialty chemicals	na	na	na	0.0	na	na	na
74 89	SCM	361	43.9	18.1	Paint	37	144.3	32.4	10.2	317	27.3	11.6
75 74	GAF	357	10.5	48.6	Specialty chemicals	79	22.3	87.2	22.1	204	45.1	36.8
76 78	Solutex	350	16.7	100.0	Basic chemicals	na	na	na	0.0	na	na	na
77 84	Mississippi Chemical	349	32.8	100.0	Farm cooperative	4	-2.9	100.0	1.2	352	100.0	1.2
78 77	Tyler	346	13.6	37.2	Diversified chemical	7	-67.3	22.9	2.1	160	33.2	4.5
79 79	Big Three Industries	339	15.6	43.7	Petroleum services	76	6.8	62.0	22.3	576	49.9	13.1
80 80	Upjohn	325	11.7	14.9	Drugs	-9	def	def	def	101	6.5	def
81 88	Chemd	318	26.2	91.8	Specialty chemicals	42	20.2	90.4	13.1	151	85.5	27.7
81 75	American Petrofina	318	2.5	14.9	Petroleum	20	293.1	38.1	6.4	308	18.8	6.6
83 —	Betz Laboratories	304	13.8	100.0	Specialty chemicals	60	18.4	100.0	19.9	221	100.0	27.4
84 86	Vulcan Materials	302	18.1	30.7	Nonmetallic minerals	47	224.0	35.8	15.6	na	na	na
85 83	Petrolite	284	6.6	98.7	Specialty chemicals	41	23.5	105.2	14.2	160	72.4	25.2
86 93	Great Lakes Chemical	278	23.1	100.0	Specialty chemicals	57	44.2	100.0	20.3	284	100.0	19.9
87 91	Aluminum Co. of America	273	13.5	4.8	Nonferrous metals	na	na	na	0.0	na	na	na
87 92	Ferro	273	13.4	41.1	Specialty materials	16	-9.8	31.7	5.8	140	42.5	11.2
89 87	Baker Industries	264	4.5	100.0	Agrochemicals	16	1521.4	100.0	6.1	341	100.0	4.8
90 85	Emhart	261	1.0	14.6	Machinery	23	-4.6	10.9	8.7	111	11.6	20.5
91 53	Kaiser Aluminum	249	-57.3	7.8	Nonferrous metals	39	58.6	67.0	15.6	261	6.0	13.8
92 94	Locite	242	12.0	100.0	Specialty chemicals	43	48.0	100.0	17.8	227	100.0	18.9
93 96	Stepan	235	13.4	100.0	Specialty chemicals	6	-45.0	100.0	2.6	134	100.0	4.6
94 —	Northwest Industries	216	2.5	15.1	Diversified	27	13.2	11.9	12.3	163	10.7	16.2
95 97	Essex Chemical	176	4.2	100.0	Basic chemicals	27	59.3	100.0	15.4	111	100.0	24.4
96 98	Agway	166	2.1	4.0	Farm cooperative	na	na	na	0.0	na	na	na
97 —	First Mississippi	165	52.5	61.2	Agrochemicals	26	37.3	64.8	17.2	82	25.9	34.6
98 100	Sterling Drug	145	6.1	7.9	Diversified	9	21.6	3.4	6.0	118	8.1	7.4
99 —	Sigma-Aldrich	138	18.4	76.9	Specialty chemicals	39	24.2	89.4	28.2	149	85.7	26.1
100 —	Crompton & Knowles	115	-1.8	50.0	Specialty chemicals	14	5.9	64.3	11.6	68	56.3	20.1

all chemical sales. ^a Fiscal year ends June 30. ^b Fiscal year ends Nov. 30. ^c Fiscal year ends Oct. 31. na = not available. def = deficit.

FINANCIAL ANALYSIS: Most measures improved modestly in 1984

			Profit margin ^a	Return on investment ^b	Debt as % of debt plus equity	% total sales abroad ^c	% total assets abroad ^d	Sales per employee ^e	Dividends as % of net income	CAPITAL SPENDING ^f		R&D as % of sales	Sales as % of assets	Net plant as % of gross plant
										as % of sales	as % of net plant			
SALES OVER \$1 BILLION														
Air Products ^g	1984	8.1%	4.2%	25.3%	17.4%	18.3%	\$ 98	23.0%	15.1%	16.5%	2.5%	74.5%	56.9%	
	1983	6.7	3.5	26.3	19.3	17.8	96	25.4	15.1	16.0	2.4	73.6	59.0	
American Cyanamid	1984	5.6	4.8	24.0	30.3	21.7	101	42.2	5.2	16.1	6.1	115.9	45.9	
	1983	4.7	4.0	24.5	32.4	23.9	91	51.3	4.7	13.1	6.1	115.7	47.9	
Celanese	1984	4.8	3.2	36.2	21.0	18.4	92	41.6	8.3	19.0	3.0	116.0	39.9	
	1983	3.6	2.5	39.7	22.0	25.1	140	56.3	3.2	7.3	2.7	113.7	38.9	
Dow Chemical	1984	4.8	3.6	35.2	53.6	45.9	229	63.2	6.8	15.1	4.4	200.5	48.0	
	1983	2.5	1.7	35.7	52.3	45.4	201	128.9	5.6	11.1	4.5	91.4	49.4	
Ethyl	1984	7.9	6.4	36.4	24.5	10.5	152	25.0	6.2	18.0	2.4	113.1	51.4	
	1983	6.6	6.8	25.6	15.5	11.1	134	31.7	4.9	13.5	2.3	115.6	51.9	
W. R. Grace	1984	2.9	3.0	40.7	18.9	14.0	84	69.8	5.6	14.1	1.2	126.3	59.3	
	1983	2.6	2.6	38.2	20.0	14.5	79	85.3	5.7	13.0	1.1	123.5	61.8	
Hercules	1984	7.7	6.8	23.5	17.7	13.2	98	40.1	8.5	24.1	2.8	107.6	46.8	
	1983	5.7	5.8	21.4	21.0	15.4	109	44.1	6.4	21.2	2.8	120.9	45.5	
International Minerals ^h	1984	7.3	4.2	27.2	20.5	8.8	170	62.3	6.8	9.2	na	78.0	55.5	
	1983	5.4	3.1	29.3	20.4	9.4	176	86.2	8.1	10.1	na	76.1	59.6	
Monsanto	1984	6.6	4.6	18.5	26.6	20.6	132	41.5	9.2	18.2	6.7	105.0	48.6	
	1983	6.2	4.1	20.4	27.0	18.2	124	43.8	8.9	17.1	4.6	98.0	49.5	
Morton Thiokol	1984	5.5	8.3	19.0	14.1	12.7	108	26.3	4.5	17.2	1.5	154.1	69.6	
	1983	5.2	6.7	21.3	15.3	16.4	90	30.1	4.7	13.6	1.5	131.1	72.8	
National Distillers	1984	3.1	3.4	25.3	na	na	na	108.2	5.2	15.5	na	118.8	58.1	
	1983	2.6	3.1	25.9	na	na	na	121.0	2.8	9.1	na	131.2	59.2	
Olin	1984	4.3	3.1	29.9	7.5	8.4	118	35.9	8.0	19.2	2.6	113.3	41.9	
	1983	3.7	2.6	31.3	7.3	9.9	106	40.9	6.3	14.4	2.6	105.8	44.1	
PPG Industries	1984	7.1	5.9	17.8	22.3	21.4	113	32.4	7.4	13.9	3.5	111.7	59.2	
	1983	6.3	4.7	21.1	22.1	22.6	100	36.9	12.2	20.5	3.5	101.9	59.6	
Pennwalt	1984	4.3	3.8	19.0	16.0	11.9	107	67.4	8.3	22.1	3.5	117.9	51.5	
	1983	4.6	3.9	26.9	16.6	12.4	100	61.2	7.1	20.0	3.4	111.9	51.2	
Rohm & Haas	1984	8.4	7.6	15.1	32.6	26.0	172	26.8	6.6	24.2	5.4	125.0	38.4	
	1983	7.5	6.4	20.1	35.4	24.6	165	27.4	3.8	13.8	5.4	124.1	38.6	
Stauffer Chemical ⁱ	1984	1.1	0.6	24.4	17.1	13.0	129	382.9	7.5	10.4	4.4	74.9	53.6	
	1983	def	def	24.8	20.3	10.9	138	def	7.7	9.2	4.7	65.4	57.9	
Union Carbide	1984	3.8	2.4	32.4	28.8	29.0	97	70.4	7.0	10.5	2.8	90.4	57.3	
	1983	2.8	1.8	32.6	31.2	30.3	90	96.3	8.5	12.1	2.7	87.4	56.7	
Williams Cos.	1984	4.3	2.8	59.3	na	na	163	29.6	7.7	8.1	na	74.7	76.5	
	1983	2.5	1.1	60.4	na	na	112	67.0	11.7	7.9	na	48.2	79.0	
Witco Chemical	1984	4.2	6.1	27.7	13.6	12.1	na	32.7	4.4	18.8	na	197.9	53.0	
	1983	3.8	6.4	30.4	14.6	13.7	na	34.8	3.2	14.3	na	189.1	53.4	
MEDIAN 1984		4.6%	3.8%	25.3%	26.5%	14.9%	\$113	41.6%	7.6%	16.5%	2.9%	113.3%	53.9%	
MEDIAN 1983		3.8%	3.3%	27.1%	28.7%	17.1%	\$111	43.5%	7.8%	13.3%	2.8%	109.6%	55.6%	

^a Net income as a percentage of sales. ^b Net income as a percentage of current assets plus gross plant. ^c Consolidated sales only. ^d Foreign, identifiable assets as a percentage of total assets. ^e Thousands of dollars. ^f Actual spending on construction of new facilities and purchase of new equipment and land in consolidated businesses. ^g For fiscal year ended Sept. 30, 1984. ^h

Finances of the U.S. Chemical Industry | 2

		Profit margin ^a	Return on investment ^b	Debt as % of total equity	% total sales abroad ^c	% total assets abroad ^d	Sales per employee ^e	Dividends as % of net income	CAPITAL SPENDING ^f		R&D as % of sales	Sales as % of assets	Net plant as % of gross plant
		as % of sales	as % of net income	as % of total equity	as % of total sales	as % of total assets	per employee	as % of net income	as % of sales	as % of net plant	as % of sales	as % of assets	as % of gross plant
SALES LESS THAN \$1 BILLION													
Baker Industries	1984	def	def	52.6%	na	na	\$311	def	5.8%	8.6%	na	77.4%	66.8%
	1983	0.4%	0.3%	52.2	22.7%	na	297	0.0	3.8	5.5	na	77.3	68.5
Betz Laboratories	1984	12.1	15.4	0.2	13.5	13.5	124	49.3	8.3	23.2	3.6	137.7	67.2
	1983	13.7	17.9	0.3	14.3	12.9	118	42.2	12.3	34.1	3.0	130.8	69.2
Chemed	1984	5.6	13.0	47.3	10.5	9.9	67	64.7	2.7	22.7	0.8	165.5	62.5
	1983	6.4	12.1	44.6	13.4	11.2	na	62.6	2.1	16.3	0.9	137.9	62.4
Crompton & Knowles	1984	3.4	5.7	21.0	16.9	19.9	100	53.2	1.7	12.7	1.9	186.0	53.7
	1983	2.7	4.6	24.6	19.3	21.2	96	61.9	1.3	9.5	1.9	182.6	56.6
Essex Chemical	1984	5.2	5.6	51.6	na	na	207	31.9	3.9	10.9	2.0	129.3	62.1
	1983	2.9	2.9	59.1	na	na	187	55.1	6.4	16.2	1.8	116.0	66.2
First Mississippi ^h	1984	5.0	3.5	31.6	na	na	335	31.0	15.2	19.6	na	70.9	59.9
	1983	6.9	3.4	35.3	na	na	251	34.8	23.2	23.6	na	53.0	64.4
Fresport-McMullan	1984	11.2	3.7	42.7	na	na	175	45.3	22.6	12.1	na	44.2	66.8
	1983	11.5	4.6	27.2	na	na	164	47.3	29.6	21.3	na	55.4	62.6
H. B. Fuller ⁱ	1984	2.9	5.0	34.0	37.7	49.8	104	20.8	2.9	14.6	2.1	189.4	65.9
	1983	3.2	5.6	36.0	39.0	50.9	104	18.1	3.5	16.3	2.0	188.4	67.0
Great Lakes	1984	12.6	10.8	16.8	na	na	167	0.9	10.2	22.0	3.5	99.6	61.0
	1983	10.5	8.5	15.1	19.9	na	na	0.7	10.4	19.3	3.4	99.5	63.9
International Flavors	1984	14.5	12.8	0.0	62.3	46.7	129	57.8	4.4	14.9	6.8	105.4	57.9
	1983	14.8	12.7	0.0	65.6	48.5	125	56.1	5.8	19.2	6.9	100.6	59.3
Lawter International	1984	15.1	16.0	7.6	31.5	29.1	na	64.4	3.4	15.6	1.8	126.3	56.1
	1983	15.9	16.1	8.1	31.3	37.6	na	59.4	3.7	15.6	1.8	119.0	59.4
Liquid Air	1984	5.4	3.5	39.9	33.9	36.9	na	78.4	12.5	16.9	1.9	55.6	56.7
	1983	5.2	3.4	31.5	34.7	35.9	113	89.5	9.1	11.7	1.8	85.8	60.5
Locite ^h	1984	10.9	11.6	10.7	39.0	45.1	98	20.5	2.8	13.6	3.1	106.3	62.2
	1983	7.9	8.2	10.8	40.5	45.0	92	32.7	4.6	21.3	2.8	101.3	66.4
Lubrizol	1984	8.1	7.6	6.0	52.0	31.6	196	64.7	3.5	11.7	3.9	118.5	48.5
	1983	8.1	7.5	5.5	52.3	36.5	192	65.4	3.1	9.1	4.6	117.2	54.7
Nalco Chemical	1984	11.0	11.6	5.1	21.5	20.9	140	64.4	7.9	25.6	4.8	138.6	48.1
	1983	10.6	11.5	5.0	21.0	21.0	143	63.9	6.1	21.1	4.5	134.8	49.3
Petrofils ^h	1984	8.8	3.3	4.6	16.9	14.9	na	47.3	3.8	15.7	3.8	132.8	43.6
	1983	7.7	7.7	5.5	19.5	15.1	na	53.8	3.2	12.3	4.0	137.7	48.2
Reichhold Chemicals	1984	3.2	5.4	16.8	10.3	11.0	191	23.7	3.0	14.1	2.3	214.4	57.5
	1983	2.7	4.2	21.6	11.1	11.4	na	31.3	2.6	11.0	2.2	194.2	59.3
Sigma-Aldrich	1984	13.5	12.6	9.3	11.6	8.4	82	16.6	6.6	25.9	na	103.1	66.1
	1983	13.1	13.4	5.3	12.3	9.9	na	19.8	5.2	20.2	na	107.2	77.4
Stapen	1984	2.3	2.7	41.6	na	na	270	38.9	4.9	15.8	3.4	175.4	51.2
	1983	3.0	3.3	27.1	na	na	235	33.3	4.7	12.9	3.4	142.6	55.9
MEDIAN 1984		8.1%	7.6%	19.8%	21.5%	29.9%	\$184	45.3%	4.4%	15.9%	3.1%	126.3%	59.9%
MEDIAN 1983		6.7%	5.2%	23.8%	21.9%	36.2%	\$154	54.5%	4.7%	16.3%	2.8%	116.6%	66.0%

For fiscal year ended June 30, 1984. ⁱ For fiscal year ended Nov. 30, 1984. ^j For fiscal year ended Nov. 30, 1984. ^k For fiscal year ended Oct. 31, 1984. Sales Net Income is from continuing operations, excluding extraordinary and nonrecurring items where possible. na = not available. def = deficit.

INDUSTRY CAPITAL SPENDING: Budgets rise to a new high for the chemical industry

\$ Billions	1985 ^a	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Chemicals	\$ 16.46	\$ 14.99	\$ 12.96	\$ 12.66	\$ 13.11	\$ 11.63	\$ 9.81	\$ 7.76	\$ 7.35	\$ 7.37	\$ 7.12
Iron and steel	3.77	3.15	3.25	3.78	3.48	3.44	3.21	2.60	2.88	3.13	3.08
Nonferrous metals	2.71	2.77	1.74	1.90	2.51	2.13	1.65	1.46	1.30	1.42	1.72
Paper	8.43	7.42	5.92	5.60	6.11	6.52	5.24	3.80	3.48	2.99	2.93
Petroleum	28.49	26.14	23.14	26.39	25.98	19.57	15.24	13.16	11.82	10.02	9.07
Rubber	2.71	2.35	2.46	2.16	2.15	2.03	2.46	2.33	1.77	1.37	1.20
Stone, clay, glass	2.89	2.61	2.77	2.90	3.41	3.98	3.99	3.15	2.30	1.91	1.67
All manufacturing	146.25	131.01	116.20	120.68	126.54	112.33	95.92	75.58	67.48	58.53	53.66

^a Estimate. Source: Department of Commerce

Chemical industry has a growing backlog of unspent capital funds

\$ Billions	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Chemicals	\$ 7.8	\$ 7.5	\$ 7.4	\$ 9.4	\$ 9.8	\$ 8.5	\$ 7.2	\$ 7.4	\$ 7.1	\$ 6.9	\$ 6.6
Iron and steel	2.1	2.2	2.7	5.4	3.9	4.5	4.0	3.6	4.7	5.4	5.8
Nonferrous metals	2.4	3.2	3.2	3.7	3.7	2.9	2.7	2.9	2.4	2.2	2.7
Paper	6.0	4.0	5.1	5.1	4.0	4.2	3.2	2.6	2.0	2.7	2.9
Petroleum, coal	25.3	22.3	22.9	29.7	26.7	16.1	14.6	15.0	12.2	14.1	12.8
Rubber	1.3	1.1	1.0	0.9	1.0	0.9	0.9	0.8	0.7	0.6	0.7
Stone, clay, glass	2.1	1.5	1.6	1.9	2.0	2.3	2.4	2.0	1.5	1.4	1.7
All manufacturing	97.2	73.7	70.8	92.7	91.9	76.7	63.4	56.5	47.5	46.4	49.8

Note: Figures are for the fourth quarter of each year. Source: Conference Board

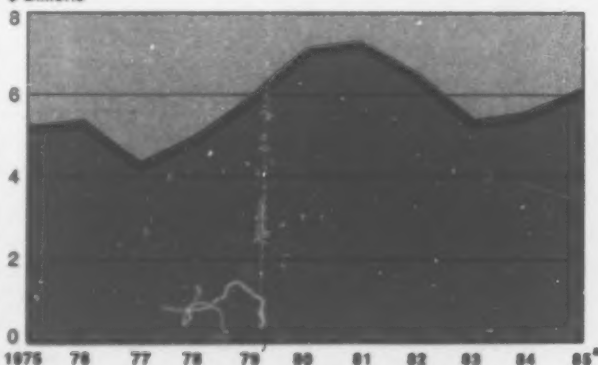
Capital spending overseas is rising for U.S. chemical firms

\$ Billions	1985 ^a	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Chemicals and allied products	\$ 3.0	\$ 2.5	\$ 2.3	\$ 2.8	\$ 3.0	\$ 3.0	\$ 2.6	\$ 1.9	\$ 2.0	\$ 2.7	\$ 2.5
Metals, primary and fabricated	1.0	1.1	0.9	0.9	0.8	0.9	0.6	0.6	0.5	0.7	0.7
Petroleum	17.3	16.2	15.5	19.7	15.8	14.8	11.0	9.5	8.9	7.9	8.9
All manufacturing	17.7	14.5	13.7	16.8	19.2	19.5	15.4	12.0	10.5	10.9	11.3

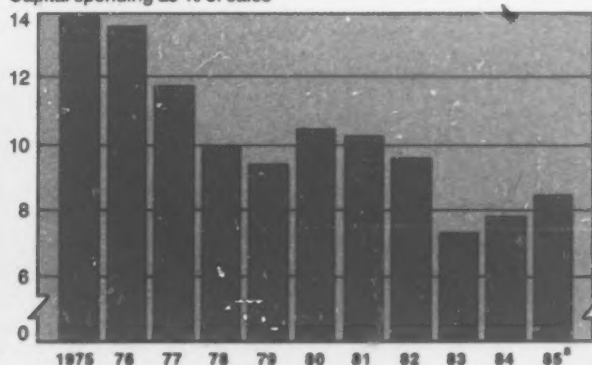
^a By majority-owned foreign affiliates of U.S. companies; data after 1976 are not consistent with earlier years. Source: Department of Commerce

Capital spending by chemical firms has recovered moderately, but is low compared to sales

\$ Billions



Capital spending as % of sales



^a Planned. Source: Worldwide data for 14 major U.S. basic chemical companies

Chemical capital spending once again is on the rise, according to a number of surveys. But these surveys don't agree on just how big that rise will be.

C&EN's survey of 14 basic chemical producers indicates that capital spending in 1984 increased 6% from 1983 to \$5.4 billion, and that these companies will spend 12% more (about \$6 billion) in 1985. Capital outlays as a percentage of sales will increase to 8.4% from 7.8% in 1984. This, however, is still below its historic level of 11 to 12%.

The Commerce Department, on the other hand, sees bigger increases for chemicals. Its survey of spending on new plant and equipment for the broader chemicals and allied products industry shows that growth of capital spending actually will slow in 1985. The Commerce Department predicts that chemical capital spending this year will rise 10% to \$16.5 billion, compared with an increase of almost 16% in 1984.

The Commerce Department survey also shows that the increase for the chemical industry will trail that for all manufacturing in 1985, with manufacturing slated to grow 12% to \$146.3 billion. But, according to the government survey, chemicals outpaced the 13% increase for all manufacturing in 1984.

A survey by the Conference Board also points to increased capital spending in 1985, based on the backlog of appropriated but unspent capital funds. This backlog increased 4% to \$7.8 billion for the chemical industry by the end of the fourth quarter of 1984 from the same period the year before. This increase is small when compared with that for all manufacturing, however. The backlog of unspent capital funds for all manufacturing at the end of the fourth quarter had climbed 32%, to a hefty \$97.2 billion, from the end of 1983.

According to the Commerce Department, overseas capital spending

by chemical producers again will be picking up this year. The department's survey of capital spending by majority-owned affiliates of U.S. firms shows that chemical capital expenditures will rise 20% to about \$3 billion in 1985, following a 9% rise in 1984. The increase in overseas spending for all manufacturing in 1985 will be 22% to \$17.7 billion, following an increase of 6% in 1984.

A resurgence in capital spending in the chemical industry is not surprising. Although in many sectors of the economy capital expenditures have been growing well since the recession, the chemical industry has been lagging. Returns on investment often did not justify the cost of money needed for capital expansion. However, capacity use in the industry continues to tighten, allowing producers to raise prices and increase profitability. At the same time, as interest rates decline, borrowing for expansion has come to look more and more attractive.

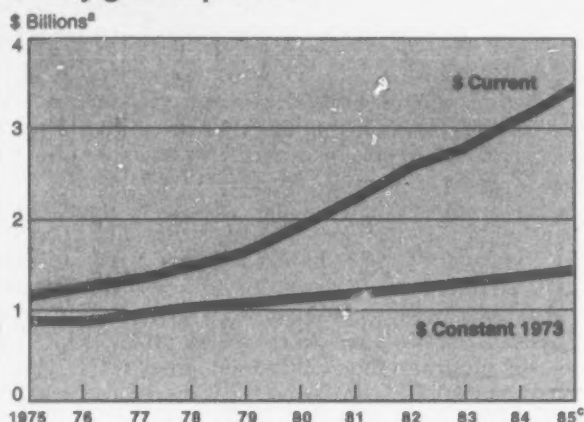
CHEMICAL CAPITAL SPENDING: Budgets for most companies are up for second straight year

\$ Millions	1985 ^a	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Air Products	\$ 325	\$ 263	\$ 246	\$ 347	\$ 323	\$ 364	\$ 246	\$ 200	\$ 143	\$ 162	\$ 151
American Cyanamid	200	200	165	171	181	196	235	251	235	232	204
Celanese	200	275	105	275	414	253	245	248	243	223	208
Dow Chemical	830	781	630	829	1176	1184	1268	1075	1163	1200	935
Du Pont ^b	1700	1185	1276	1300	1420	1297	864	714	704	876	1036
Ethyl	116	103	85	92	141	156	123	96	88	88	69
W. R. Grace	420	380	353	560	657	658	514	313	279	234	309
Hercules	210	218	168	174	167	229	186	116	127	150	151
Monsanto	575	614	560	673	668	781	566	480	607	647	528
Olin	170	165	123	139	186	172	161	163	208	166	99
PPG Industries	400	315	450	452	376	401	252	261	212	177	176
Rohm & Haas	130	134	72	126	182	93	68	66	79	110	106
Stauffer Chemical	137	112	104	177	239	246	239	201	193	199	199
Union Carbide	650	670	761	1179	1186	1129	831	688	805	965	862
TOTAL	\$6063	\$5415	\$5097	\$6493	\$7316	\$7159	\$5798	\$4872	\$5086	\$5429	\$5033
ANNUAL CHANGE	12%	6%	-21%	-11%	2%	23%	19%	-4%	-6%	8%	18%

^a Planned. ^b Excludes Conoco. Note: Figures are for worldwide spending on construction, equipment, and land in consolidated businesses. Where possible, acquisition costs and investments in nonconsolidated businesses are excluded. Source: Company data.

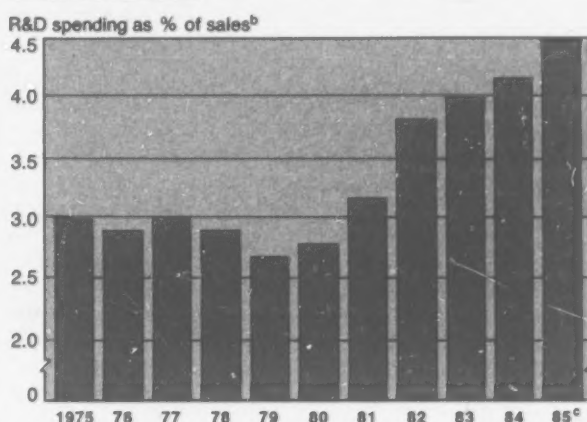
2 Finances of the U.S. Chemical Industry

Chemical companies' R&D budgets maintain steady growth pace ...



^a R&D spending by 15 basic chemical companies. ^b For 15 basic chemical companies. ^c Estimated.
Sources: Worldwide data for 15 U.S. basic chemical companies, Battelle Columbus Laboratories, C&EN estimates

... as spending wins a bigger share of total revenues



R&D spending by the U.S. chemical industry is rising a solid 10% this year, according to C&EN's survey of 15 basic chemical companies. Although down slightly from the 11% rise recorded in 1984, the planned increase marks the second consecutive year of double-digit growth for research budgets.

More significant, major chemical producers are devoting a greater share of their resources to research. R&D spending as a per cent of corporate sales stayed mostly below 3% throughout the 1970s, reaching a low of 2.7% in 1979. Growth has been uninterrupted since then and will soar to 4.5% this year.

With most large chemical producers scrambling to develop value-added products targeted for specialty

markets, it is not surprising that R&D spending is surging. In the 1970s, chemical companies concentrated on process research, seeking incremental improvements in the production economics of commodity chemicals. Now many are emphasizing product research, which tends to be more expensive. The rate of introducing new products, particularly specialty polymers and agricultural chemicals, has increased.

Adjusted for anticipated inflation in R&D costs, research spending will rise just under 4% this year, a small amount compared to the constant-dollar increases of the early 1980s. That figure looks better, however, considering the likelihood that chemical sales, adjusted for inflation, will rise little if at all in 1985.

CHEMICAL R&D SPENDING: Double-digit increases continue for second year

\$ Millions	1985 ^a	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Air Products	\$ 51	\$ 44	\$ 40	\$ 37	\$ 32	\$ 30	\$ 24	\$ 23	\$ 24	\$ 19	\$ 16
American Cyanamid	250	237	215	190	172	148	130	108	96	83	73
Celanese	105	94	85	100	104	94	92	83	77	70	64
Dow Chemical	530	507	492	460	404	314	269	232	203	188	167
Du Pont ^b	1100	1000	875	775	647	591	509	461	367	353	336
Ethyl	42	40	39	39	37	34	29	25	28	25	19
W. R. Grace	90	79	71	62	55	45	42	37	32	28	30
Hercules	79	72	74	74	65	57	50	43	40	37	32
Lubrizol	38	38	37	36	33	28	23	21	19	17	17
Monsanto	450	370	290	264	233	208	161	136	132	114	116
Olin	53	54	51	47	39	31	26	25	25	23	24
PPG Industries	185	150	127	127	119	103	83	70	61	56	50
Rohm & Haas	120	109	100	92	77	67	54	49	45	43	39
Stauffer Chemical ^c	68	66	63	57	49	44	35	32	32	28	23
Union Carbide	280	265	245	240	207	166	161	156	156	143	120
TOTAL	\$3441	\$3125	\$2804	\$2600	\$2273	\$1960	\$1688	\$1501	\$1337	\$1227	\$1126
ANNUAL CHANGE	10%	11%	8%	14%	16%	16%	12%	12%	9%	9%	9%

^a Planned. ^b Excludes petroleum and coal segments. ^c All figures are restated for fiscal year ending Sept. 30; Stauffer Chemical was acquired by Chasebrough-Pond's in first-quarter 1985.
Sources: Company data and estimates

INDUSTRY BALANCE SHEET: Little change overall but liquidity is lower

Industrial chemicals and synthetics

Assets	1984 (\$ billions)	1983 (\$ billions)	Change
Current assets:			
Cash on hand and in U.S. banks	\$ 1.10	\$ 1.28	-14%
Short-term securities	1.29	1.57	-18
Receivables	13.12	14.01	-8
Inventories	12.26	11.60	6
Other current assets	2.89	2.25	28
Total	30.65	30.71	0
Fixed assets:			
Property, plant, and equipment			
Depreciable fixed assets	82.17	79.31	4
Land and mineral rights	3.44	3.18	8
Less: accumulated depreciation and depletion	41.48	38.24	8
Net fixed assets	44.13	44.25	0
Other assets, including investments and intangibles	19.27	17.20	12
TOTAL ASSETS	\$94.06	\$92.16	2%

Source: Bureau of the Census

Liabilities and stockholders' equity	1984 (\$ billions)	1983 (\$ billions)	Change
Current liabilities			
Short-term debt	\$ 1.89	\$ 1.74	8%
Accounts payable	6.75	6.79	-1
Accrued income taxes	1.44	1.24	16
Current portion of long-term debt	1.27	1.11	14
Other current liabilities	9.69	8.91	9
Total	21.04	19.79	6
Long-term debt	18.14	19.43	-7
Other noncurrent liabilities, including deferred taxes and minority interest	8.02	7.88	4
TOTAL LIABILITIES	47.19	46.91	1
Stockholders' equity			
Capital stock and other capital	17.06	17.79	-4
Retained earnings	29.82	27.47	9
TOTAL STOCKHOLDERS' EQUITY	46.87	45.26	4
TOTAL LIABILITIES AND STOCKHOLDERS' EQUITY	\$94.06	\$92.16	2%

DEBT RATIOS: At the lowest level in a decade for chemical producers

\$ Billions	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
INDUSTRIAL CHEMICALS AND SYNTHETICS											
Long-term debt	\$18.1	\$19.4	\$22.0	\$21.4	\$19.8	\$14.8	\$13.6	\$12.3	\$11.8	\$10.2	\$ 7.8
Stockholders' equity	\$46.9	\$45.3	\$45.9	\$42.5	\$39.8	\$32.3	\$29.3	\$26.3	\$25.0	\$22.8	\$20.5
Debt ratio ^a	27.9%	30.0%	32.4%	33.5%	29.6%	31.4%	31.8%	31.9%	32.0%	30.8%	27.6%
CHEMICALS AND ALLIED PRODUCTS											
Long-term debt	\$35.9	\$36.2	\$38.2	\$36.9	\$28.3	\$24.9	\$23.5	\$21.1	\$19.4	\$16.8	\$12.8
Stockholders' equity	\$101.5	\$97.2	\$95.3	\$89.9	\$79.5	\$67.4	\$60.8	\$54.9	\$50.8	\$45.7	\$40.9
Debt ratio ^a	26.1%	27.2%	28.6%	29.1%	26.3%	27.0%	27.9%	27.8%	27.6%	26.9%	23.8%
ALL MANUFACTURING											
Long-term debt	\$325.8	\$286.6	\$293.1	\$266.5	\$236.2	\$204.8	\$182.0	\$167.3	\$153.6	\$145.2	\$130.1
Stockholders' equity	\$884.2	\$837.6	\$783.0	\$762.3	\$699.7	\$624.0	\$560.8	\$511.7	\$475.3	\$435.5	\$408.4
Debt ratio ^a	26.9%	25.5%	27.2%	25.9%	25.2%	24.7%	24.5%	24.6%	24.4%	25.0%	24.2%

^a Long-term debt as a percentage of long-term debt plus stockholders' equity. Note: Because of changes in accounting rules and industry classifications, numbers over the entire range of years are not strictly comparable. Source: Bureau of the Census

CASH FLOW: With profits up last year, borrowing becomes less important as a source of funds

\$ Millions, % of total	1984	1983	1982	1981	1980
SOURCES OF FUNDS					
Net income	\$ 3,917 29.5%	\$ 2,735 21.5%	\$ 2,347 19.4%	\$ 3,629 17.1%	\$3354 33.9%
Depreciation and depletion	4,699 35.4	4,633 36.4	4,346 36.0	3,633 17.1	3275 33.1
Deferred taxes	591 4.4	362 2.8	570 4.7	908 4.3	603 6.1
Other internal sources	2,496 18.8	2,591 20.4	1,841 15.2	1,308 6.1	496 5.0
Long-term debt	1,551 10.9	1,899 14.9	2,554 21.1	7,190 33.9	1892 19.1
Stock	135 1.0	514 4.0	427 3.5	4,567 21.5	282 2.8
TOTAL	\$13,288 100.0%	\$12,734 100.0%	\$12,085 100.0%	\$21,233 100.0%	\$9902 100.0%
APPLICATIONS OF FUNDS					
Dividends	\$ 1,891 14.2%	\$ 1,754 13.8%	\$ 1,682 13.9%	\$ 1,569 7.4%	\$1368 13.8%
Capital expenditures	6,335 47.7	5,619 44.1	7,192 59.5	6,975 32.9	5867 59.3
Additions to working capital	-16 -0.1	-343 -2.7	-1,548 -12.8	3,576 16.8	648 6.5
Reduction of long-term debt	2,649 19.9	3,380 26.6	3,398 28.1	1,081 5.1	968 9.8
Other applications	2,429 18.3	2,324 18.2	1,361 11.3	8,032 37.8	1050 10.6
TOTAL	\$13,288 100.0%	\$12,734 100.0%	\$12,085 100.0%	\$21,233 100.0%	\$9902 100.0%

Note: Data are totals for 12 major chemical companies: American Cyanamid, Celanese, Dow Chemical, Du Pont, Ethyl, Hercules, Monsanto, Olin, Penwalt, Rohm & Haas, Union Carbide, and Williams Cos. Source: Company annual reports

2 Finances of the U.S. Chemical Industry

Last year brought continued improvement to the financial status of U.S. producers of chemicals and drugs. This is clear from the annual data for 33 individual chemical companies and 16 pharmaceutical firms presented on this and the following four pages.

With production up nearly 7% for basic chemicals and synthetic materials nationwide, 90% of the chemical companies reported higher sales in 1984 than in the year before. Higher earnings were equally widespread. For nearly three fourths of the companies, in fact, earnings did even better than sales, with a resulting widening of profit margins. With chemicals more in demand and adequate cash flow from income and depreciation available about four out of five of the companies hiked their spending for new plant and equipment. At the

same time, a strong majority also were more generous to stockholders; 70% of the companies raised dividend payments during 1984.

Despite the gains of the past couple of years, however, for a majority of the chemical companies earnings remained below the levels of four or five years ago. Profitability, too, was still less than it had been in the early 1980s.

The annual figures for 1984, moreover, cloud the trend in financial results as the year developed. Growth in sales and earnings was strongest during the early months of the year and weakened steadily as the year progressed. This trend is continuing during the first half of 1985. Profits so far this year, in fact, are trailing significantly behind those of early last year.

Explanation of table headings

Year. Data are for calendar year unless otherwise indicated.

Net sales. Gross sales, less discounts, allowances, and returns; generally excludes excise taxes and other operating income or revenues.

Net income. Net sales and other income, less operating costs, nonoperating charges, depreciation, depletion, interest expense, deferred charges, minority interest in income, and taxes. Nonrecurring or extraordinary credits and charges have been excluded in most cases, but these items are indicated by a footnote.

Total assets. Sum at year's end of current assets, investments, prepaid expenses, net plant and equipment, and other tangible assets. Excludes insofar as possible intangible assets including goodwill, value of patents and trademarks, and the like.

Current ratio. The ratio of current assets (cash, marketable securities, receivables, and inven-

tories but excluding prepaid expenses) to total current liabilities.

Net plant and equipment. Value at year's end of fixed assets, less accumulated depreciation, amortization, and depletion.

Capital expenditures. Total spending during the year for new fixed assets, such as plant, equipment, and land, and for replacement and modernization of facilities.

Net worth. Equity at year's end of preferred and common stock holders, including value of capital stock, capital and earned surplus, and surplus reserves, as well as contingency and miscellaneous reserves for which no definite purpose is stated. Intangible assets are deducted insofar as possible.

Net income (breakdown). Per cent of sales: net income divided by net sales. Per cent of net worth: net income divided by tangible net worth. Dollars per share: net income, less preferred dividends,

divided by the number of shares of common stock outstanding. All figures are adjusted for stock splits, but no adjustment has been made for earlier years as a result of stock dividends or for dilution that might result from the conversion of preferred stock or debt to common stock or the exercise of stock options outstanding.

Dividends per share. Cash dividends paid (or declared) on each share of common stock; excludes the value of stock dividends, which are indicated by a footnote.

Dividend yield. Dividends per share divided by the average of the high and low prices of the common stock during the calendar year.

Stock price range. High-low market prices of common stock during the calendar year, adjusted for stock splits but not for stock dividends.

Price-earnings ratio. Average of the high and low prices of the common stock during the calendar year divided by net income per share.

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, \$ per share	Dividend yield, % of price	Stock price range, \$ per share	Price-earnings ratio
								% of sales	% of net worth	\$ per share				
Money figures in thousands of dollars unless otherwise indicated														
CHEMICALS														
Air Products & Chemicals														
1984*	\$1,735,115	\$140,618	\$2,267,457	1.1	\$1,587,382	\$262,491	\$1,058,328	8.1%	13.3%	\$4.55	\$1.05	2.5%	\$48 1/2-36 1/2	9.3
1983*	1,634,246	108,963	2,160,157	1.1	1,541,345	246,417	988,256	6.7	11.0	3.55	0.90	2.1	51-34	12.0
1982*	1,568,916	105,654 ^a	2,118,882	1.2	1,497,162	346,680	867,565	6.7	12.2	3.68 ^a	0.80	2.5	41 1/2-23 1/2	8.8
1981*	1,570,115	126,030	1,871,986	1.2	1,301,922	322,465	769,134	8.0	16.4	4.42	0.80	1.9	40 1/2-34	9.4
American Cyanamid Co.														
1984	\$3,856,725	\$215,918	\$3,304,027	1.9	\$1,241,927	\$200,110	\$1,645,122	5.6%	13.1%	\$4.41	\$1.86	3.9%	\$53 1/2-42 1/2	10.8
1983	3,535,514	165,356	3,031,311	2.1	1,255,658	165,068	1,578,875	4.7	10.5	3.41	1.75	3.8	58-33 1/2	13.6
1982	3,453,674	132,127	2,985,004	2.0	1,296,204	171,047	1,526,390	3.8	8.7	2.74	1.75	5.7	37 1/2-24 1/2	11.3
1981	3,649,073	197,054	3,049,917	1.9	1,325,063	180,897	1,513,457	5.4	13.0	4.11	1.675	5.5	36 1/2-24 1/2	7.4
Baker Industries Corp.														
1984	\$264,125	(\$6,842) ^a	\$341,087	1.1	\$178,710	\$15,278	\$115,622	—	—	(\$0.58) ^a	0.00	0.0	\$11 1/2-5 1/2	—
1983	252,730	1,001 ^a	326,818	1.1	176,725	9,687	112,460	0.4%	0.9%	0.08 ^a	0.00	0.0	12 1/2-5 1/2	110.9
1982	210,185	(5,256) ^a	304,073	0.8	178,796	18,534	102,015	—	—	(0.44) ^a	0.00	0.0	8 1/2-3 1/2	—
1981	206,913	1,254 ^a	342,935	1.0	189,135	65,486	115,289	0.6	1.1	0.11 ^a	0.00	0.0	25-7 1/2	147.7
Betz Laboratories														
1984	\$303,680	\$36,737	\$220,662	2.1	\$123,296	\$25,302	\$170,684	12.1%	21.5%	\$2.33	\$1.10	3.3%	\$ 39-27 1/2	14.2
1983	286,983	33,100	204,174	2.1	110,872	32,795	161,766	12.4	20.5	2.08	0.94	2.4	44 1/2-32 1/2	18.5
1982	254,717	30,561	186,320	2.0	87,382	24,769	143,421	12.0	21.3	1.93	0.82	2.4	42 1/2-24 1/2	17.4
1981	252,545	28,815	165,660	2.7	71,914	16,525	126,799	11.4	22.7	1.83	0.82	2.5	33 1/2-21 1/2	15.0

a Fiscal year ends Sept. 30. b Excludes extraordinary gain for debt-for-equity exchange of \$2.8 million (\$0.10 per share) and credit for cumulative effect of change in accounting principle for investment tax credit of \$61.9 million (\$2.16 per share). c Net loss. d Excludes extraordinary net gain on termination of pension plan of \$1.8 million (\$0.16 per share). e Net loss; excludes net loss from discontinued operations and their disposition of \$8.0 million (\$0.68 per share). f Excludes net loss from discontinued operations of \$6.1 million (\$0.52 per share).

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment Money figures in thousands of dollars unless otherwise indicated	Capital expenditures	Net worth	NET INCOME			Dividends, \$ per share	Dividend yield, % of price	Stock price range, \$ per share	Price-earnings ratio
								% of sales	% of net worth	\$ per share				
Big Three Industries														
1984	\$775,678	\$ 56,896	\$1,152,791	2.1	\$820,807	\$ 96,897	\$566,272	7.3%	10.0%	\$1.40	\$0.80	3.7%	\$24 1/2-18 1/2	15.4
1983	668,041	45,331	1,097,602	3.0	763,863	71,581	615,720	6.8	7.4	1.07	0.74	3.2	27 1/2-18 1/2	21.6
1982	767,785	86,812	1,055,313	3.0	773,777	162,293	609,792	11.3	14.2	2.05	0.72	3.3	28 1/2-15 1/2	10.6
1981	823,280	108,854	1,015,259	2.7	680,769	158,234	555,765	13.2	18.6	2.57	0.60	1.9	37 1/2-25	12.2
Cabot Corp.														
1984 ^a	\$1,752,523	\$ 97,073	\$1,730,722	1.8	\$1,051,251	\$116,911	\$699,167	5.5%	13.9%	\$3.02	\$0.92	3.6%	\$28 1/2-27 1/2	8.5
1983 ^a	1,558,016	64,162	1,293,340	2.6	656,894	76,964	658,838	4.1	9.7	2.00	0.92	3.6	30 1/2-20 1/2	12.8
1982 ^a	1,587,658	88,007	1,300,553	2.2	664,434	138,342	624,069	5.5	14.1	2.77	0.92	4.4	25 1/2-16 1/2	7.5
1981 ^a	1,622,755	110,167	1,238,729	2.2	595,234	192,348	586,226	6.8	18.8	3.50	0.86	2.9	35 1/2-23 1/2	8.5
Celanese Corp.														
1984	\$3,328,000	\$161,000	\$3,104,000	1.6	\$1,349,000	\$169,000	\$1,099,000	4.8%	14.6%	\$10.87	\$4.10	5.7%	\$ 82-62 1/2	6.7
1983	3,261,000	112,000	2,869,000	1.7	1,445,000	105,000	1,169,000	3.4	9.6	6.89	4.00	6.4	79 1/2-45	9.1
1982	3,062,000	(34,000) ^b	2,862,000	1.9	1,808,000	275,000	1,131,000	...	...	(2.45) ^b	4.00	7.9	59 1/2-41 1/2	...
1981	3,752,000	144,000	2,991,000	2.0	1,518,000	414,000	1,233,000	3.6	11.7	9.01	3.85	6.4	69 1/2-51 1/2	6.7
Chemed Corp.														
1984	\$346,140	\$20,110	\$180,518	1.7	\$45,517	\$9,198	\$ 49,822	5.9%	40.4%	\$2.29	\$1.49	4.7%	\$36 1/2-25 1/2	13.6
1983	271,343	17,371 ^a	174,248	1.9	35,012	5,703	58,420	6.4	29.7	2.17 ^a	1.36	3.8	39 1/2-32	16.4
1982	249,019	16,824 ^a	152,735	1.7	30,887	5,008	36,448	6.8	46.2	1.79 ^a	1.25	4.7	36 1/2-17 1/2	14.9
1981	250,638	23,166 ^a	216,915	2.7	29,583	5,481	188,542	10.0	14.9	1.26 ^a	1.14	5.2	25-19	17.5
Crompton & Knowles Corp.														
1984	\$230,434	\$7,891	\$114,135	2.5	\$30,809	\$3,917	\$58,586	3.4%	13.2%	\$2.31	\$1.14	5.3%	\$23 1/2-19 1/2	9.3
1983	230,560	6,302	115,536	2.6	31,205	2,954	57,893	2.7	10.9	1.81	1.06	4.6	28 1/2-16 1/2	12.6
1982	213,250	5,199	117,902	2.6	33,055	3,582	59,320	2.4	8.8	1.44	1.04	6.6	19 1/2-12 1/2	9.1
1981	243,412	8,571	132,197	2.3	32,668	6,699	63,606	3.5	13.5	2.51	0.95	6.1	18 1/2-12 1/2	6.2
Dow Chemical Co.														
1984	\$11,418,000	\$549,000 ^a	\$11,217,000	1.5	\$5,173,000	\$ 781,000	\$4,860,000	4.8%	11.3%	\$2.83	\$1.80	6.0%	\$34 1/2-25 1/2	10.6
1983	10,951,000	293,000 ^a	11,785,000	1.4	5,695,000	630,000	4,851,000	2.7	6.0	1.50 ^a	1.80	5.7	38 1/2-25	21.1
1982	10,618,000	342,000 ^a	11,612,000	1.8	5,961,000	829,000	4,845,000	3.2	7.1	1.77 ^a	1.80	7.4	28 1/2-19 1/2	13.7
1981	11,873,000	564,000	12,268,000	1.7	6,174,000	1,176,000	4,663,000	4.8	12.1	3.00	1.80	5.8	39-23 1/2	10.4
E. I. du Pont de Nemours & Co.														
1984	\$35,915,000	\$1,431,000	\$24,098,000	1.6	\$14,409,000	\$2,931,000	\$12,233,000	4.0%	11.7%	\$5.93	\$2.90	6.1%	\$52 1/2-42 1/2	8.0
1983	35,378,000	1,127,000	24,432,000	1.7	14,261,000	2,628,000	11,472,000	3.2	9.8	4.70	2.50	5.5	55-35 1/2	9.6
1982	33,331,000	894,000	24,343,000	1.7	14,004,000	3,295,000	10,850,000	2.7	8.2	6.75	2.40	6.5	44 1/2-30	9.9
1981	22,816,000	1,081,000 ^a	23,829,000	2.0	12,722,000	2,389,000	10,458,000	4.7	10.3	5.81 ^a	2.75	6.0	56-35 1/2	7.9
Ethyl Corp.														
1984	\$1,675,050	\$132,184	\$1,437,207	2.2	\$573,156	\$103,416	\$707,716	7.9%	18.7%	\$1.72	\$0.425	3.2%	\$18 1/2-10	7.7
1983	1,745,193	106,038	1,449,982	2.0	626,461	84,723	811,260	6.1	13.1	1.40	0.425	3.9	14 1/2-7 1/2	8.4
1982	1,614,626	94,166	1,458,534	2.2	666,186	91,915	766,175	5.8	12.3	1.17	0.375	5.7	8 1/2-4 1/2	5.6
1981	1,757,195	90,891	1,194,630	2.2	658,282	140,520	683,001	5.2	13.3	1.14	0.375	5.3	8 1/2-5 1/2	6.2
Ferro Corp.														
1984	\$662,867	\$16,886	\$359,938	2.0	\$136,462	\$29,364	\$185,963	2.5%	9.1%	\$2.53	\$1.20	4.0%	\$38 1/2-22 1/2	12.0
1983	619,179	19,228	364,861	1.9	132,509	21,252	185,337	3.1	10.4	3.04	1.20	3.7	39 1/2-24 1/2	10.6
1982	595,830	10,277	345,922	2.0	133,318	22,650	161,945	1.7	6.3	1.37 ^a	1.20	4.9	30 1/2-18 1/2	17.9
1981	702,213	25,503	389,405	2.1	135,587	24,243	222,441	3.6	11.5	3.30	1.20	4.6	31 1/2-29 1/2	7.9
First Mississippi Corp.														
1984 ^a	\$270,004	\$15,845 ^a	\$380,855	1.5	\$209,742	\$41,034	\$166,957	5.9%	9.5%	\$0.77 ^a	\$0.24	2.3%	\$13 1/2-7 1/2	13.8
1983 ^a	203,976	14,146	379,436	1.3	200,990	47,428	155,055	8.9	9.1	0.89	0.24	2.0	15 1/2-8 1/2	17.2
1982 ^a	222,977	23,212 ^a	394,587	1.0	183,994	67,882	145,407	10.4	16.0	1.11 ^a	0.24	2.2	16-8	9.9
1981 ^a	357,697	29,704	318,926	1.5	117,244	58,277	138,384	8.3	21.5	1.38	0.23	1.2	20 1/2-13 1/2	14.2
W. R. Grace & Co.														
1984	\$6,727,800	\$195,600	\$5,193,000	1.6	\$2,704,200	\$390,100	\$2,063,300	2.9%	9.5%	\$4.02	\$2.80	6.7%	\$46 1/2-36 1/2	10.4
1983	6,219,500	159,700 ^a	4,946,600	1.6	2,715,400	353,100	2,094,300	2.6	7.6	3.29 ^a	2.80	6.3	50 1/2-38 1/2	13.5
1982	6,127,600	319,500 ^a	4,854,300	1.7	2,706,400	559,500	2,136,600	5.2	15.0	6.62 ^a	2.70	7.2	46 1/2-28 1/2	5.6
1981	6,520,800	361,300 ^a	4,947,100	1.5	2,528,600	656,900	1,986,600	5.5	18.2	7.59 ^a	2.45	5.0	59 1/2-38 1/2	6.5
Great Lakes Chemical Corp.														
1984	\$278,235	\$35,568	\$276,469	2.2	\$130,784	\$28,770	\$164,805	12.8%	21.6%	\$2.38	\$0.36	1.1%	\$38 1/2-24	13.2
1983	225,950	23,842	217,916	2.1	121,411	23,393	132,286	10.6	18.0	1.63	0.36	1.1	39 1/2-16 1/2	17.3
1982	169,703	13,945 ^a	192,127	2.2	113,659	19,143	111,782	8.2	12.5	0.99 ^a	0.26	1.6	20 1/2-12 1/2	16.9
1981	150,333	18,031	170,190	1.9	98,580	22,777	106,878	12.0	16.6	1.25	0.22	0.9	29 1/2-18 1/2	18.0

a Fiscal year ends Sept. 30. b Net loss; includes special charge related to 40% equity in Mexican affiliate of \$39 million (\$2.50 per share). c Excludes net gain on disposition of discontinued Dearborn Group operations of \$875,000 (\$0.11 per share). d Excludes net income from discontinued Dearborn Group operations of \$1.9 million (\$0.11 per share). e Excludes net income from discontinued Dearborn Group operations of \$11.2 million (\$0.56 per share). f Includes pretax gain on sales of investments of \$184 million but excludes tax benefits from realization of foreign tax loss carry-forwards of \$36 million (\$0.19 per share). g Includes pretax gain on sales of investments of \$101 million but excludes extraordinary net gain on debt-for-equity exchange of \$41 million (\$0.21 per share). h Includes pretax gain on sales of investments of \$214 million but excludes extraordinary net gain on debt-for-equity exchange of \$57 million (\$0.30 per share). i Excludes cumulative effects of change in accounting for investment tax credits of \$320 million (\$1.74 per share). j Includes loss on divestitures of \$1.9 million (\$0.23 per share). k Fiscal year ends June 30. l Excludes net gain from disposal of FirstMiss subsidiary of \$120,170 (\$0.01 per share). m From continuing operations; excludes net loss from discontinued FirstMiss subsidiary of \$6.4 million (\$0.30 per share). n Includes net gains on disposal of businesses of \$5.7 million. o Includes gain on restructuring Chemed Corp. of \$65.1 million and net losses on disposal of business of \$600,000. p Includes net gains on disposal of business of \$31.1 million. q Excludes net gain on sale of real estate of \$2.5 million (\$0.34 per share).

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, \$ per share	Dividend yield, % of price	Stock price range, \$ per share	Price-earnings ratio
								% of sales	% of net worth	\$ per share				
Money figures in thousands of dollars unless otherwise indicated														
Hercules														
1984	\$2,570,935	\$197,185	\$2,388,489	2.4	\$906,031	\$218,105	\$1,366,911	7.7%	14.4%	\$3.54	\$1.48	4.5%	\$ 38-27 1/4	9.2
1983	2,628,954	174,222	2,175,173	2.1	793,313	167,993	1,288,118	6.6	13.5	3.17	1.38	3.9	43 1/4-27 1/4	11.1
1982	2,468,971	86,861 ^a	2,001,354	2.2	923,676	164,997	1,078,911	3.5	8.1	1.97 ^a	1.32	5.8	28 1/4-18 1/4	11.6
1981	2,718,366	136,481	1,997,144	2.5	907,733	167,189	1,051,357	5.0	13.0	3.09	1.26	5.6	26 1/4-18 1/4	7.3
International Flavors & Fragrances														
1984	\$476,678	\$69,242	\$452,392	4.4	\$140,109	\$20,942	\$351,183	14.5%	19.7%	\$1.89	\$1.08	4.1%	\$29 1/4-22 1/4	13.8
1983	460,945	68,410	458,262	3.5	139,921	26,851	344,255	14.8	19.9	1.87	1.04	3.5	35 1/4-23 1/4	15.9
1982	447,889	63,160	431,589	4.1	135,565	28,369	335,902	14.1	18.8	1.73	1.01	4.3	30-17 1/4	13.7
1981	451,088	66,123	430,890	3.8	125,975	16,558	329,878	14.7	20.0	1.81	0.94	4.6	23-17 1/4	11.3
International Minerals & Chemical Corp.														
1984 ^b	\$1,532,900	\$112,000 ^a	\$1,965,600	1.9	\$2,061,400	\$104,800	\$1,039,100	7.3%	10.8%	\$4.17 ^a	\$2.60	6.4%	\$ 49-32 1/4	9.8
1983 ^b	1,462,000	80,500	1,943,900	1.9	1,983,700	119,300	1,024,100	5.5	7.9	3.02	2.60	6.5	49-31 1/4	13.3
1982 ^a	1,580,400	122,300 ^d	1,941,900	1.8	1,869,900	161,600	1,010,200	7.8	12.1	4.56 ^d	2.60	8.6	36 1/4-23 1/2	6.6
1981 ^b	1,984,900	153,800	1,975,200	1.7	1,896,300	336,600	975,300	7.7	15.8	5.63	2.46	5.1	66 1/2-30 1/2	8.6
Liquid Air Corp.														
1984	\$501,735	\$27,304	\$549,821	1.8	\$370,530	\$82,461	\$246,667	5.4%	11.1%	\$2.07	\$1.60	7.7%	\$ 23-18 1/2	10.0
1983	459,409	23,902	500,573	1.5	354,796	41,620	244,849	5.2	9.8	1.80	1.60	7.2	26 1/4-18 1/2	12.4
1982	448,996	27,512	503,090	1.8	353,376	58,657	247,801	6.1	11.1	2.13	1.60	9.1	20 1/4-14 1/4	8.3
1981	427,991	31,529 ^b	465,128	1.6	285,026	61,818	239,776	7.4	13.1	2.86 ^b	1.55	6.7	29 1/4-16 1/4	8.1
Lubrizol Corp.														
1984 ^b	\$241,744	\$26,349	\$223,694	2.0	\$45,696	\$ 6,172	\$129,526	10.9%	20.3%	\$2.67	\$0.64	1.7%	\$42 1/4-30 1/4	13.7
1983 ^b	215,892	17,128	209,387	2.2	46,789	9,955	129,419	7.9	13.2	1.72	0.56	1.5	46 1/4-28 1/2	21.8
1982 ^a	216,450	15,778	196,069	2.4	44,083	10,824	119,752	7.3	13.2	1.59	0.56	2.3	30 1/4-18 1/4	15.4
1981 ^b	213,912	10,377	177,099	2.8	42,792	13,201	116,999	4.9	8.9	1.05	0.56	2.3	31-18 1/4	23.4
Loctite Co.														
1984	\$831,681	\$67,731	\$701,974	2.8	\$251,735	\$29,490	\$474,343	8.1%	14.3%	\$1.73	\$1.12	5.2%	\$24 1/2-18 1/4	12.4
1983	789,546	64,744 ^f	682,864	2.8	274,337	25,003	471,521	8.2	13.7	1.65 ^f	1.08	4.7	27 1/4-18 1/4	13.9
1982	801,284	47,561	643,744	2.6	288,504	51,589	462,044	5.9	10.3	1.21	1.08	5.7	23 1/4-14 1/4	15.7
1981	878,291	92,031	673,165	2.6	284,088	75,399	478,518	10.5	19.2	2.36	1.08	3.9	35 1/2-20 1/4	11.8
Monsanto Co.														
1984	\$6,891,000	\$439,000	\$6,373,000	2.0	\$3,374,000	\$614,000	\$3,634,000	6.6%	12.1%	\$5.42	\$2.25	4.8%	\$53 7/8-40 1/8	11.5
1983	6,299,000	369,000 ^a	6,427,000	2.1	3,284,000	560,000	3,667,000	5.9	10.1	4.48 ^a	2,075	4.4	58 1/4-37 1/4	10.6
1982	6,325,000	329,000 ^a	6,077,000	2.4	3,313,000	673,000	3,490,000	5.2	9.4	4.10 ^a	1,975	5.4	44 1/4-28 1/4	8.9
1981	6,947,700	445,100 ^f	6,069,200	2.2	3,183,900	667,900	3,330,200	6.4	13.4	5.75 ^f	1,875	5.1	43 1/4-29 1/4	6.4
Nalco Chemical Co.														
1984	\$664,303	\$73,086 ^f	\$479,271	2.4	\$205,103	\$52,478	\$352,120	11.0%	20.8%	\$1.86 ^f	\$1.20	4.4%	\$33 1/4-21	14.6
1983	659,403	71,000	489,095	2.3	191,791	40,505	350,471	10.8	20.3	1.78	1.14	3.5	37-28	18.3
1982	643,863	64,356 ^a	464,868	2.2	194,450	56,241	336,488	10.0	19.1	1.62 ^a	1.12	4.3	34-18	16.0
1981	666,501	81,209	466,175	2.2	176,959	59,423	335,974	12.2	24.2	2.02	1.00	4.0	29 1/4-20 1/2	12.3
Olin Corp.														
1984	\$2,065,328	\$88,747	\$1,822,099	1.9	\$860,658	\$165,000	\$867,307	4.3%	10.2%	\$3.81	\$1.365	4.7%	\$33 1/2-25 1/4	7.7
1983	1,934,579	71,715	1,829,416	1.9	850,936	122,580	848,355	3.7	8.5	3.01	1.23	4.3	34-23	9.5
1982	1,823,137	62,800 ^f	1,636,027	1.7	839,974	139,015	805,185	3.4	7.8	2.66 ^f	1.20	5.7	26 1/4-15 1/2	7.8
1981	2,001,346	92,836	1,618,034	1.6	844,927	186,331	793,187	4.6	11.7	3.88	1.15	4.9	27-19 1/2	6.0
Pennwalt Corp.														
1984	\$1,047,214	\$45,356	\$868,673	1.9	\$393,765	\$87,177	\$485,325	4.3%	9.3%	\$3.31	\$2.20	6.0%	\$42 1/4-31 1/4	11.1
1983	976,741	44,796 ^a	851,082	2.6	348,190	89,808	458,077	4.6	9.8	3.50 ^a	2.20	5.9	45 1/4-29	10.4
1982	952,400	24,502 ^a	737,048	1.6	342,785	76,466	346,364	2.6	7.1	2.37 ^a	2.20	7.8	34 1/4-21 1/4	11.9
1981	1,056,118	36,661 ^a	755,755	2.1	309,525	52,696	367,098	3.5	10.0	3.55 ^a	2.20	7.1	36-26 1/4	8.8
Reichhold Chemicals														
1984	\$801,355	\$25,709	\$371,819	2.0	\$172,219	\$24,228	\$206,421	3.2%	12.5%	\$3.63	\$0.65	2.2%	\$35 1/4-23	7.5
1983	747,263	21,700	362,273	2.0	175,722	19,305	211,081	2.9	10.3	2.74	0.51	1.8	38 1/4-18 1/4	10.4
1982	814,911	6,875 ^a	364,133	2.5	159,181	20,516	200,546	0.8	3.4	0.57 ^a	0.48	3.2	19 1/4-10	26.0
1981	950,112	17,054 ^a	405,477	2.3	173,398	15,908	206,727	1.8	8.2	2.04 ^a	0.48	3.5	16-11 1/4	6.6
Rohm & Haas Co.														
1984	\$2,042,011	\$172,219	\$1,633,029	2.0	\$515,945	\$134,253	\$865,146	8.4%	17.8%	\$6.73	\$1.80	3.1%	\$89 1/4-48 1/8	8.7
1983	1,875,937	137,603	1,511,244	2.7	518,360	71,534	904,393	7.3	15.2	5.33	1.50	2.5	81-37 1/4	11.1
1982	1,828,027	85,605 ^a	1,365,163	2.5	546,623	125,927	807,853	4.7	10.6	3.32 ^a	1.40	4.5	39 1/4-22 1/4	9.4
1981	1,884,664	93,065 ^a	1,348,627	2.4	537,489	181,835	759,911	4.9	12.2	3.61 ^a	1.28	4.3	35 1/4-23 1/4	8.2

a Excludes extraordinary net gain on debt-for-equity exchange of \$11.6 million (\$0.25 per share). b Fiscal year ends June 30. c Excludes net loss from operations and disposal of discontinued methanol joint venture of \$30.3 million (\$1.13 per share). d From continuing operations; excludes earnings and net gain on disposal of discontinued chemical operations of \$15.1 million (\$0.57 per share). e Includes net gain on sale of assets, before taxes, of \$1.0 million. f Includes net gain on sale of investments of \$7.5 million (\$0.19 per share). g Excludes extraordinary net tax benefits from utilization of ex-U.S. loss carry-forwards of \$33 million (\$0.40 per share). h Excludes extraordinary net gain on debt-for-equity exchange of \$23 million (\$0.29 per share) but includes net loss on sale of European acrylic fibers business of \$18 million (\$0.23 per share). i Includes net gain on sale of joint venture of \$67.7 million (\$0.87 per share). j Excludes net income from discontinued lead antiknock compound operations of \$3.1 million (\$0.08 per share). k Excludes net loss on discontinued Industrial Bio-Test Laboratories operations of \$6.2 million (\$0.16 per share). l Excludes special charge for DDT claims, net, of \$9.5 million (\$0.40 per share). m Includes gain on sale, retirement, and revaluation of assets, before taxes, of \$2.17 million. n From continuing operations; excludes provision for loss on disposal of discontinued operations of \$2.8 million (\$0.27 per share). o From continuing operations; includes cost of shutdown of chlorine-caustic plant, before taxes, of \$21.5 million but excludes net loss on operation and disposal of discontinued businesses of \$11.4 million (\$1.10 per share) and nonrecurring net gain from cumulative effect of change in accounting for investment credit of \$16.3 million (\$1.57 per share). p Excludes net loss resulting from asset redeployment/divestiture program of \$2.2 million (\$0.32 per share). q Excludes extraordinary net charge for settlement of litigation of \$2.4 million (\$0.34 per share). r Includes net gain on shutdown and disposal of assets of \$10.4 million (\$0.40 per share). s Includes net loss from shutdown and disposal of assets of \$8.6 million (\$0.25 per share).

Finances of the U.S. Chemical Industry 2

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, \$ per share	Dividend yield, % of price	Stock price range, \$ per share	Price-earnings ratio
								% of sales	% of net worth	\$ per share				
Money figures in thousands of dollars unless otherwise indicated														
Stepan Co.														
1984	\$234,930	\$5,423 ^a	\$132,941	1.8	\$73,281	\$11,557	\$47,660	2.3%	11.4%	\$1.66	\$0.65	3.9%	\$18 ¹ / ₂ -14 ¹ / ₂	10.0
1983	207,074	6,337	144,997	1.5	76,044	9,804	58,450	3.1	16.8	1.75	0.58	3.9	17 ¹ / ₂ -12	8.4
1982	208,373	5,303	163,326	1.3	75,475	16,148	55,067	2.5	9.6	1.45	0.56	4.1	18 ¹ / ₂ -9 ¹ / ₂	9.4
1981	204,522	6,545 ^b	176,068	1.5	67,906	12,083	53,888	3.2	12.1	1.74	0.515	3.0	21 ¹ / ₂ -12 ¹ / ₂	9.8
Sun Chemical Corp.														
1984	\$872,948	\$25,218	\$587,932	2.0	\$178,292	\$38,052	\$174,164	2.9%	14.5%	\$3.23	\$0.48	1.7%	\$ 33-24 ¹ / ₂	8.9
1983	746,609	9,529	497,715	1.8	141,771	27,666	157,917	1.3	6.0	1.24	0.48	2.0	30 ¹ / ₂ -17 ¹ / ₂	19.6
1982	664,257	14,871 ^a	523,799	1.9	134,351	27,371	162,130	2.2	9.2	1.97 ^c	0.48	2.6	24 ¹ / ₂ -13 ¹ / ₂	9.5
1981	598,776	35,349 ^d	523,282	2.1	122,397	32,708	176,601	5.9	20.0	4.73 ^d	0.48	1.9	31 ¹ / ₂ -19 ¹ / ₂	5.4
Union Carbide Corp.														
1984	\$ 9,508,000	\$341,000 ^a	\$18,402,000	1.3	\$6,383,000	\$ 670,000	\$4,808,000	3.6%	7.1%	\$4.84 ^a	\$3.40	6.9%	\$85 ¹ / ₂ -32 ¹ / ₂	10.1
1983	9,001,000	218,000 ^c	10,226,000	1.1	6,282,000	761,000	4,860,000	2.4	4.5	3.11 ^f	3.40	5.4	73 ¹ / ₂ -51	20.1
1982	9,061,000	310,000	10,552,000	1.1	6,356,000	1,179,000	5,095,000	3.4	6.1	4.47	3.40	6.7	61-40 ¹ / ₂	11.3
1981	10,168,000	649,000	10,366,000	2.1	5,794,000	1,186,000	5,206,000	6.4	12.5	9.56	3.30	6.1	82 ¹ / ₂ -45 ¹ / ₂	5.6
Williams Cos.														
1984	\$3,388,700	\$144,500 ^a	\$4,534,000	1.6	\$3,252,800	\$262,000	\$1,284,000	4.3%	11.3%	\$4.21	\$1.25	4.6%	\$31 ¹ / ₂ -23	6.5
1983	2,187,000	34,000	4,686,409	0.7	3,193,000	253,400	1,173,900	2.5	4.6	1.79	1.20	5.1	30 ¹ / ₂ -16 ¹ / ₂	13.1
1982	1,691,315	29,682 ^b	2,369,791	1.7	1,513,712	171,895	1,029,411	1.8	2.9	1.00 ^b	1.20	5.6	29 ¹ / ₂ -13 ¹ / ₂	21.2
1981	1,976,336	99,157 ^d	2,445,677	1.6	1,497,797	233,184	1,027,245	5.0	9.7	3.32 ^d	1.20	3.4	46 ¹ / ₂ -23 ¹ / ₂	10.6
Wilco Chemical Corp.														
1984	\$1,495,831	\$82,002	\$739,438	2.2	\$348,740	\$65,720	\$358,497	4.2%	17.5%	\$4.28	\$1.40	4.2%	\$39 ¹ / ₂ -27 ¹ / ₂	7.8
1983	1,385,744	52,022	715,472	2.1	313,794	44,901	319,334	3.8	16.3	3.60	1.26	4.6	37 ¹ / ₂ -17 ¹ / ₂	7.6
1982	1,305,418	29,842	643,911	2.2	291,914	54,130	281,013	2.3	10.6	2.10	1.20	7.2	19 ¹ / ₂ -13 ¹ / ₂	8.0
1981	1,291,878	38,580	707,181	1.7	281,945	55,479	277,973	3.0	13.9	2.76	1.10	6.1	21-15 ¹ / ₂	6.6
PHARMACEUTICALS														
Abbott Laboratories														
1984	\$3,103,982	\$402,575	\$3,172,897	1.7	\$1,236,572	\$334,800	\$1,602,700	13.0%	25.1%	\$3.34	\$1.20	2.8%	\$48 ¹ / ₂ -36 ¹ / ₂	12.8
1983	2,927,873	347,817	2,824,128	1.7	1,069,200	311,800	1,417,883	11.9	24.5	2.86	1.00	2.2	53 ¹ / ₂ -36 ¹ / ₂	15.6
1982	2,602,447	289,123	2,566,909	1.1	901,059	286,600	1,310,886	11.1	22.1	2.37	0.84	2.5	41 ¹ / ₂ -25 ¹ / ₂	14.1
1981	2,342,524	247,283	2,355,613	1.1	729,402	212,400	1,152,050	10.6	21.5	2.01	0.72	2.6	32 ¹ / ₂ -23 ¹ / ₂	13.9
American Home Products Corp.														
1984	\$4,485,470	\$655,829 ^a	\$2,840,732	3.3	\$769,623	\$141,891	\$1,905,733	14.6%	34.4%	\$4.26 ^b	\$2.64	5.2%	\$55 ¹ / ₂ -46 ¹ / ₂	12.0
1983	4,856,501	627,233	2,864,104	2.9	812,370	204,680	1,826,964	12.9	34.3	4.00	2.40	5.0	54 ¹ / ₂ -41 ¹ / ₂	12.0
1982	4,582,096	560,103	2,602,346	2.6	725,352	153,812	1,614,192	12.2	34.7	3.59	2.15	5.3	48-33 ¹ / ₂	11.3
1981	4,131,237	497,332	2,517,541	3.0	492,879	99,852	1,583,475	12.0	31.4	3.18	1.90	5.8	37 ¹ / ₂ -28 ¹ / ₂	10.3
Baxter Travenol Laboratories														
1984	\$1,800,422	\$145,147 ^a	\$2,000,753	1.5	\$767,636	\$171,852	\$1,106,731	8.1%	13.1%	\$1.03	\$0.33	1.8%	\$24 ¹ / ₂ -11 ¹ / ₂	17.8
1983	1,842,544	218,055	2,127,037	1.6	746,304	192,464	1,151,109	11.8	18.9	1.54	0.28	1.1	31 ¹ / ₂ -20	16.6
1982	1,671,445	186,885	1,792,710	1.9	628,720	148,812	1,061,009	11.2	17.6	1.32	0.23	1.1	25 ¹ / ₂ -15 ¹ / ₂	15.4
1981	1,583,890	150,581	1,590,743	2.8	583,084	87,101	978,325	10.0	15.4	1.07	0.19	1.3	16 ¹ / ₂ -12	13.4
Bristol-Myers Co.														
1984	\$4,189,400	\$472,400	\$3,100,800	2.4	\$791,100	\$191,000	\$1,998,100	11.3%	23.6%	\$3.45	\$1.50	3.2%	\$52 ¹ / ₂ -41	13.8
1983	3,917,000	408,000	2,888,300	2.2	701,700	165,000	1,788,900	10.4	22.8	3.00	1.16	2.9	47 ¹ / ₂ -31 ¹ / ₂	13.2
1982	3,599,900	348,700	2,665,800	2.2	653,600	170,000	1,624,000	9.7	21.5	2.59	1.02	3.3	37-25 ¹ / ₂	12.0
1981	3,496,700	305,800	2,406,000	2.2	581,800	150,300	1,482,000	8.7	20.6	2.29	0.89	3.4	29 ¹ / ₂ -22 ¹ / ₂	11.4
Eli Lilly & Co.														
1984	\$3,109,200	\$400,200	\$3,556,500	1.8	\$1,280,400	\$205,300	\$2,133,800	15.9%	23.0%	\$6.73	\$2.975	4.9%	\$67 ¹ / ₂ -53	9.0
1983	3,033,700	457,400	3,401,200	1.7	1,212,600	199,900	2,108,400	15.1	21.6	6.13	2.75	4.4	68 ¹ / ₂ -56 ¹ / ₂	10.2
1982	2,962,711	411,821	3,155,125	1.8	1,135,575	236,642	2,055,480	13.9	20.0	5.42	2.60	4.7	65 ¹ / ₂ -45 ¹ / ₂	10.2
1981	2,773,295	374,478	2,902,252	1.9	1,006,180	253,735	1,888,260	13.5	19.8	4.93	2.375	4.2	68 ¹ / ₂ -45 ¹ / ₂	11.6

a Includes nonrecurring net loss on writedown of equipment of \$2.6 million. b Includes loss of sale of flavor compounding business, before taxes, of \$890,000. c From continuing operations; excludes equity in net loss of affiliate's discontinued operations of \$12.9 million (\$1.71 per share). d From continuing operations; includes gains on disposition of product lines of \$8.4 million but excludes equity in net loss of affiliate's discontinued operations of \$9.4 million (\$1.26 per share). e Excludes extraordinary charge relating to accident in Bhopal, India, of \$16 million (\$0.25 per share). f Excludes nonrecurring net charge for closing of facilities of \$139 million (\$1.98 per share). g Excludes net loss and net gain on disposition of Edgcomb Metals Co. operations of \$5.0 million (\$0.15 per share). h From continuing operations; excludes net income from discontinued operations of \$4.7 million (\$0.15 per share). i From continuing operations; excludes net income from discontinued operations of \$10.4 million (\$0.35 per share). j From continuing operations; excludes net income and net gain on sale of discontinued businesses of \$76.3 million (\$0.50 per share). k Excludes special net charge for closing three plants and revaluation of assets of \$116.1 million (\$0.62 per share).

2 Finances of the U.S. Chemical Industry

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, \$ per share	Dividend yield, % of price	Stock price range, \$ per share	Price-earnings ratio
								% of sales	% of net worth	\$ per share				
Money figures in thousands of dollars unless otherwise indicated														
Merck & Co.														
1984	\$3,559,665	\$482,967	\$4,489,697	1.9	\$1,912,778	\$274,425	\$2,443,260	13.8%	20.2%	\$6.71	\$3.00	3.4%	\$ 97½-78½	13.1
1983	3,246,139	450,855	4,119,098	1.7	1,715,207	272,756	2,339,013	13.9	19.3	6.10	2.80	3.0	104½-81½	15.3
1982	3,063,017	415,137	3,591,652	1.9	1,557,490	295,106	2,147,988	13.6	19.3	5.61	2.80	3.7	88½-64	13.6
1981	2,925,455	398,265	3,310,000	1.7	1,395,567	322,814	2,001,460	13.6	19.9	5.36	2.60	2.9	103-76½	16.7
Pfizer														
1984	\$3,854,500	\$507,900	\$3,927,700	2.1	\$1,155,600	\$144,000	\$2,365,100	13.2%	21.5%	\$3.08	\$1.32	3.7%	\$42½-29½	11.6
1983	3,750,000	447,100	3,830,000	2.0	1,157,000	214,900	2,074,700	11.9	21.6	2.73	1.16	3.0	44½-33½	14.4
1982	3,453,600	332,800	3,644,500	1.9	1,124,700	265,500	1,869,500	9.6	17.8	2.13	0.92	2.8	40½-25	15.3
1981	3,249,700	273,700	3,544,200	1.9	998,200	287,100	1,594,700	8.4	17.2	1.82	0.80	3.4	27½-20	13.1
Richardson-Vicks														
1984*	\$1,280,500	\$71,900	\$733,100	2.1	\$231,600	\$27,400	\$281,600	5.6%	25.5%	\$2.92	\$1.48	5.4%	\$30½-24½	9.3
1983*	1,115,700	51,400	755,000	1.8	241,600	34,030	264,900	4.6	19.4	2.10	1.48	5.6	29½-23½	12.7
1982*	1,115,600	66,900	687,100	2.0	247,000	57,500	394,600	6.0	17.0	2.74	1.48	5.6	32½-20½	9.7
1981*	1,088,100	83,200	672,200	1.7	208,600	49,300	365,300	7.6	22.8	3.47	1.32	4.7	34½-21½	8.1
A. H. Robins Co.														
1984	\$631,891	(\$461,613) ^d	\$565,627	1.5	\$135,685	\$38,155	(\$210,353) ^a	—	—	(\$18.44) ^d	\$0.72	4.1%	\$23¼-12¼	—
1983	563,510	58,221 ⁱ	459,462	3.1	107,651	20,955	305,636	10.3%	19.0%	2.40	0.62	2.7	29½-16	9.5
1982	482,324	48,693 ^a	386,843	3.8	98,079	15,815	267,945	10.1	18.2	1.98	0.52	3.3	20½-11½	7.9
1981	450,854	44,228 ^a	385,483	3.0	96,457	28,103	251,742	9.8	17.6	1.77	0.44	3.8	14½-8½	6.6
Schering-Plough Corp.														
1984	\$1,874,300	\$177,200	\$2,436,200	1.2	\$912,400	\$173,700	\$1,235,100	9.5%	14.3%	\$3.50	\$1.68	4.6%	\$ 40-323	10.4
1983	1,808,500	178,500 ⁱ	2,309,800	1.3	841,400	177,700	1,186,500	9.9	15.0	3.40 ⁱ	1.68	4.0	48½-36½	12.5
1982	1,817,900	183,500	2,341,200	1.8	747,500	180,400	1,278,500	10.1	14.4	3.39	1.68	4.8	43½-26½	10.3
1981	1,808,800	179,300	2,214,500	1.9	654,600	170,300	1,254,200	9.9	14.3	3.31	1.66	4.9	42½-24½	10.2
G. D. Searle & Co.														
1984	\$1,245,800	\$161,600 ⁱ	\$1,582,000	2.0	\$496,400	\$191,900	\$803,000	13.0%	20.1%	\$3.24	\$0.52	1.0%	\$65½-37½	15.9
1983	946,000	119,000 ^a	1,278,100	2.3	361,900	124,800	668,100	12.6	17.8	2.39 ^a	0.52	1.1	55½-34½	19.0
1982	1,036,900	140,500	1,204,500	2.1	377,800	135,200	599,700	13.5	23.4	2.77	0.52	1.4	45½-28½	13.3
1981	942,300	130,900 ⁱ	1,050,400	2.3	279,300	87,600	533,600	13.9	24.5	2.52 ⁱ	0.52	1.7	35½-25½	12.0
SmithKline Corp.														
1984	\$500,300 ^m	\$3,077,600	2.0	\$1,093,000	\$241,500	\$1,952,100	17.0%	25.6%	\$6.19 ^m	\$2.80	5.1%	\$60½-50	8.9	
1983	485,990 ⁿ	3,085,409	1.8	988,857	232,914	1,970,793	17.1	24.7	5.85 ⁿ	2.65	4.0	76½-55½	11.3	
1982	2,900,967	455,157	2,765,900	2.1	971,302	304,784	1,749,407	15.3	26.0	5.51	2.39	3.5	77½-57½	12.3
1981	1,985,341	370,000	1,796,105	2.3	580,920	200,816	1,138,457	18.6	32.5	5.55	2.12	2.8	88½-63½	13.7
Squibb Corp.														
1984	\$1,886,037	\$197,172	\$2,072,188	2.1	\$617,724	\$115,629	\$1,266,517	10.5%	15.6%	\$3.68	\$1.48	3.2%	\$54½-37½	12.5
1983	1,768,891	173,274 ^a	1,887,783	2.2	564,613	109,800	1,173,399	9.8	14.8	3.31 ^a	1.365	2.8	55½-42½	14.9
1982	1,660,766	153,636	1,871,882	2.1	511,821	87,280	1,037,939	9.3	14.8	3.01	1.28	3.2	50½-29	13.2
1981	1,523,911	41,099 ^b	1,900,424	2.1	479,720	69,851	979,689	2.7	4.2	0.83 ^b	1.215	3.8	37½-26½	38.7
Sterling Drug														
1984	\$1,827,295	\$144,853 ^a	\$1,429,618	2.5	\$370,273	\$73,158	\$894,943	7.9%	16.2%	\$2.39 ^a	\$1.15	4.3%	\$ 30-23½	11.2
1983	1,901,171	136,844	1,437,440	2.5	366,328	63,189	879,655	7.2	15.6	2.24	1.1	4.3	29½-22½	11.6
1982	1,796,153	131,970	1,297,989	2.6	356,535	80,068	825,944	7.3	16.0	2.17	1.06	4.3	21½-19½	11.4
1981	1,792,925	130,303	1,226,410	2.5	334,980	77,016	787,542	7.3	16.5	2.15	0.98	4.3	26½-19	10.5
Upjohn Co.														
1984	\$2,179,060	\$173,272	\$2,248,363	1.5	\$809,534	\$136,738	\$1,134,154	8.0%	15.3%	\$5.67	\$2.56	4.4%	\$72½-45	10.3
1983	1,986,106	160,225	2,195,048	1.9	754,954	155,016	1,057,288	8.1	15.2	5.28	2.35	4.1	68½-46½	10.9
1982	1,828,730	126,020	2,013,985	1.9	675,869	137,273	973,028	6.9	13.0	4.18	2.28	4.7	59½-38	11.6
1981	1,898,334	181,764	1,940,485	2.0	614,481	139,211	965,267	9.6	18.8	6.04	2.07	3.6	88-45½	9.5
Warner-Lambert Co.														
1984	\$3,166,657	\$223,887	\$2,377,098	1.5	\$863,179	\$142,461	\$ 910,125	7.1%	24.6%	\$2.81	\$1.48	4.6%	\$36½-28½	11.5
1983	3,108,325	200,496	2,368,879	1.7	826,232	165,854	869,980	6.5	23.0	2.51	1.42	4.7	35-25½	12.1
1982	3,245,967	174,970 ^r	2,344,259	1.9	768,571	153,507	815,864	5.4	21.4	2.20 ^r	1.40	5.6	30½-19½	11.3
1981	3,379,952	9,222 ^a	2,662,418	1.7	869,753	165,833	1,094,796	0.3	0.9	0.12 ^a	1.34	6.4	25-17½	175.5

a From continuing operations; excludes net loss from discontinued diagnostic imaging operations and provision for loss on disposal of discontinued operations of \$52.4 million (\$0.34 per share). b Fiscal year ends June 30. c From continuing operations; excludes net loss from discontinued ethical pharmaceutical businesses of \$3.9 million (\$0.16 per share). d Net loss; includes income, before taxes, from litigation settlement of \$1.2 million and net charge for reserve for Dalkon Shield claims of \$489.1 million (\$19.53 per share). e Deficit. f Includes income, before taxes, from litigation settlement of \$2.3 million. g Includes income, before taxes, from litigation settlement of \$3.1 million. h Includes income, before taxes, from litigation settlement of \$3.4 million. i From continuing operations; excludes net gain on sale of discontinued home products business of \$11.6 million (\$0.22 per share). j Includes gain, before taxes, on sale of Pearl Health Services shares of \$6.1 million. k From continuing operations; includes gain, before taxes, on sale of Pearl Health Services shares of \$39.0 million but excludes net income and gain on sale of discontinued specialty gas and Australian specialty chemical operations of \$32.2 million (\$0.65 per share). l From continuing operations; excludes net loss from operations and disposition of discontinued businesses of \$26.0 million (\$0.50 per share) and debit for cumulative effect of changes in accounting principles of \$6.2 million (\$0.12 per share). m Excludes net gain on sale of Industrial Business Group of \$3.3 million (\$0.04 per share). n From continuing operations; excludes net income of discontinued Industrial Business Group of \$3.5 million (\$0.04 per share). o Excludes extraordinary net gain on early extinguishment of debt of \$27.0 million (\$0.52 per share) and net loss on disposal of Latin American operations of \$27.6 million (\$0.53 per share). p From continuing operations; excludes net gain on sale of confectionery products business of \$58.1 million (\$1.16 per share), net income from that business of \$12.2 million (\$0.24 per share), and extraordinary charge relating to takeover of operations in Iran of \$6.5 million (\$0.13 per share). q From continuing operations; excludes net loss on operations of divested environmental control business of \$1.5 million (\$0.02 per share). r Includes nonrecurring net credit of \$12 million (\$0.15 per share). s Includes nonrecurring net charge of \$134 million (\$1.68 per share).

Chemical workforce growing sluggishly

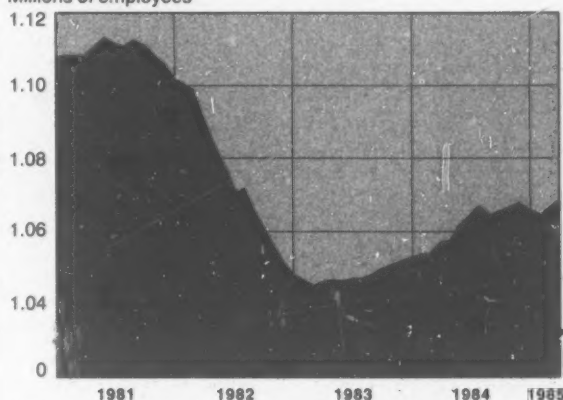
Although in 1984 the number of workers in the U.S. chemical industry increased to about 1,061,000, the workforce remains significantly smaller than when it began to drop precipitously in late 1981. Moreover, the slow but steady recovery in jobs that started in mid-1983 flattened out by mid-1984. Employment in the petroleum industry continued to drop last year, but rubber manufacturers added workers.

No segment of the chemical industry cut employees in 1984, but rebuilding is fastest in such product areas as drugs, soap, toiletries, paint, and miscellaneous chemical products, where the number of workers has rebounded to the level of 1982. The industrial and agricultural chemicals sectors have shown little or no increase in their workforces in the past year, however.

Major chemical firms as a whole added employees in 1984 after three years of decline. However, some of the largest—such as Union Carbide, Monsanto, and Dow Chemical—continued to trim employment.

Chemical employment continues slow recovery from 1983 lows

Millions of employees^a



^a Seasonally adjusted employment in U.S. chemicals and allied products industry. March and April 1985 figures are preliminary. Source: Department of Labor

INDUSTRIAL EMPLOYMENT: Higher last year in chemicals, but under 1982 level

	All employees ^a (thousands)				Production workers ^a (thousands)				Workweek ^{a,b} (hours)			
	1984	1983	1982	1974	1984	1983	1982	1974	1984	1983	1982	1974
All manufacturing	19,590	18,497	18,781	20,077	13,455	12,581	12,742	14,638	40.7	40.1	38.9	40.0
Chemicals and allied products	1,061	1,047	1,075	1,080	589	581	599	823	41.9	41.6	40.9	41.5
Industrial inorganic chemicals	157	155	161	149	80	79	86	92	42.2	41.5	40.4	42.4
Plastics materials and synthetics	176	176	185	248	116	114	119	163	42.3	42.0	40.6	41.2
Drugs	201	200	199	168	94	98	98	86	40.7	41.0	41.1	41.3
Soap, cleaners, and toilet goods	148	143	144	125	94	90	90	74	41.4	41.1	40.6	40.5
Paints and allied products	62	60	60	67	30	29	29	37	41.7	41.0	39.6	40.5
Industrial organic chemicals	163	163	171	150	83	84	86	76	43.0	42.5	41.9	42.7
Agricultural chemicals	61	61	65	82	38	37	40	40	42.8	42.1	42.0	42.5
Miscellaneous chemical products	94	90	91	91	54	51	51	55	41.8	41.3	40.5	41.0
Petroleum and coal products	188	196	201	197	110	118	120	126	43.7	43.9	43.9	42.1
Rubber and miscellaneous plastics products	796	718	697	695	621	556	534	545	41.7	41.2	39.6	40.5

^a Domestic employment. ^b Workweek of production or nonsupervisory workers. Source: Department of Labor

EMPLOYMENT OF SCIENTISTS, ENGINEERS: Growth in chemical sector is slowing

Thousands ^a	1984 ^b	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Total, all industry	537.8	522.1	509.8	487.8	450.6	423.9	404.4	382.8	364.4	363.3	360.0
Chemicals and allied products	67.5	66.0	61.6	54.7	51.4	50.0	48.3	46.4	44.4	45.2	41.8
Industrial chemicals	26.7	27.2	25.9	21.6	20.9	21.4	21.3	20.6	20.1	21.1	19.1
Drugs and medicines	30.3	28.2	25.6	23.3	21.6	20.8	19.5	17.8	16.6	15.6	14.0
Other chemicals	10.5	10.6	10.1	9.8	8.9	7.8	7.5	8.0	7.8	8.5	8.7
Petroleum refining	13.4	14.7	15.6	13.0	10.8	10.1	9.9	8.9	8.6	8.4	8.2
Rubber products	na	na	8.1	10.3	na	8.1	7.9	9.1	8.6	8.4	7.7

^a Full-time equivalent number of R&D scientists and engineers in industry, as of January of each year. ^b Preliminary. na = not available separately, but included in total. Source: National Science Foundation

CHEMICAL EMPLOYMENT: Up slightly last year after three years of decline

Thousands	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Air Products	17.7	16.7	18.9	16.2	15.8	14.6	14.3	13.7	13.4	13.0
American Cyanamid	38.2	38.7	40.2	41.8	42.6	44.2	44.0	43.8	39.4	37.8
Celanese	36.0	23.3	25.3	35.9	36.5	33.3	33.2	32.1	31.9	37.0
Crompton & Knowles	2.3	2.4	2.3	2.5	2.8	3.0	3.2	3.1	3.0	2.2
Dow Chemical	49.8	54.5	56.6	63.8	56.8	55.9	53.5	53.2	53.0	53.0
Ethyl	11.0	13.0	14.0	14.5	15.0	16.0	16.5	16.0	16.0	17.0
Freeport-McMoran	4.8	4.8	5.0	5.2	2.7	3.9	3.5	3.7	3.8	3.5
H. B. Fuller	4.3	4.1	4.0	3.3	3.4	3.4	3.3	3.0	2.8	2.6
W. R. Grace	80.0	78.5	82.2	89.0	91.7	82.1	68.5	66.7	63.8	65.3
Hercules	26.3	24.2	24.5	22.8	22.9	24.4	24.5	24.0	24.0	23.5
International Flavors	3.7	3.7	3.6	3.6	3.6	3.6	3.5	3.3	3.1	2.9
International Minerals	9.0	8.4	8.4	10.6	10.6	10.3	9.9	9.9	9.7	10.5
Lubrizol	4.2	4.2	4.3	4.2	4.2	3.9	3.8	3.6	3.6	3.6
Monsanto	50.8	50.9	51.2	57.4	61.8	63.9	62.9	61.5	61.9	59.2
Nalco Chemical	4.8	4.6	4.6	4.7	4.4	4.1	4.1	4.2	3.8	3.5
Olin	17.8	18.2	17.5	20.3	21.0	21.7	22.7	22.4	22.0	23.0
Pennwalt	9.8	9.8	9.5	10.7	12.8	13.3	14.0	13.9	13.9	14.3
PPG Industries	37.7	37.0	37.0	36.6	37.3	38.2	37.4	36.6	36.3	34.9
Reichhold Chemicals	4.2	3.6	4.5	5.6	5.6	6.4	6.5	6.5	5.8	4.3
Rohm & Haas	11.9	11.4	11.5	13.5	13.2	13.3	13.1	13.0	13.3	13.8
Stauffer Chemical	11.7	9.7	11.0	12.2	13.4	13.8	13.1	13.0	13.0	13.1
Stepan	0.9	0.9	0.9	0.9	0.8	0.9	0.8	0.8	0.7	0.7
Union Carbide	98.4	99.5	103.2	110.3	116.1	115.8	113.4	113.7	113.1	106.5
TOTAL EMPLOYEES	535.3	522.0	540.3	585.6	595.0	590.0	589.7	563.7	551.3	545.2
ANNUAL CHANGE	2.5%	-3.4%	-7.7%	-1.6%	0.8%	3.6%	1.1%	2.2%	1.1%	-4.0%
SALES PER EMPLOYEE (\$ thousands, current)	\$122.3	\$116.6	\$110.7	\$110.9	\$103.5	\$95.8	\$91.1	\$74.7	\$68.8	\$51.3
SALES PER EMPLOYEE (\$ thousands, constant 1972 ^a)	\$ 42.4	\$ 41.5	\$ 39.5	\$ 40.2	\$ 41.4	\$44.9	\$47.8	\$40.4	\$38.3	\$29.5

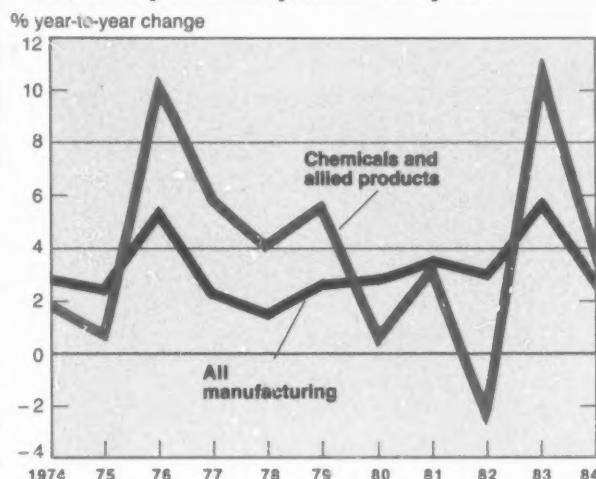
^a Based on producer price index for chemicals and allied products. Note: Data are not restated for acquisitions and similar adjustments.

WAGES: Increases in 1984 for chemical workers outpaced those for all industry

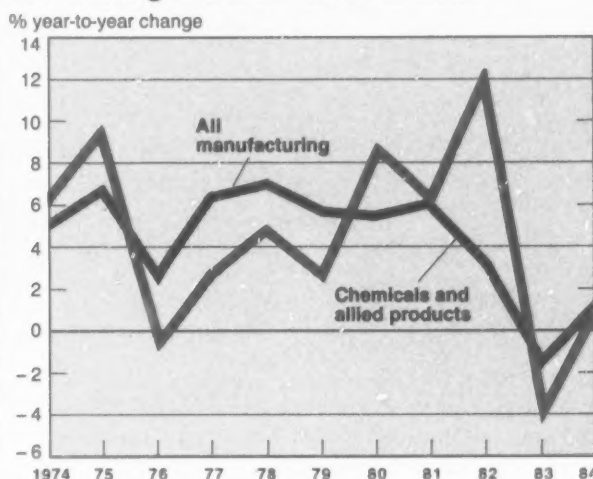
	Hourly earnings ^a				Weekly earnings ^a			
	1984	1983	1982	1974	1984	1983	1982	1974
All manufacturing	\$ 9.17	\$ 8.83	\$ 8.49	\$4.42	\$373.22	\$354.08	\$330.26	\$176.80
Chemicals and allied products	11.11	10.59	9.96	4.88	465.51	440.54	407.36	202.52
Industrial inorganic chemicals	12.34	11.68	11.01	5.27	520.75	484.72	444.80	217.65
Plastics materials and synthetics	11.15	10.56	9.87	4.70	471.65	443.52	400.72	193.64
Drugs	10.24	9.72	9.08	4.70	416.77	398.52	373.19	194.11
Soap, cleaners, and toilet goods	9.93	9.66	9.12	4.75	411.10	397.03	370.27	192.38
Paints and allied products	9.74	9.33	8.80	4.55	406.16	382.53	348.48	184.28
Industrial organic chemicals	13.42	12.73	11.85	5.62	577.06	541.03	496.52	239.97
Agricultural chemicals	10.73	10.24	9.69	4.41	459.24	431.10	406.98	187.43
Miscellaneous chemical products	10.08	9.63	9.22	4.65	421.34	397.72	373.41	190.65
Petroleum and coal products	13.45	13.29	12.46	5.68	587.77	583.43	546.99	239.13
Rubber and miscellaneous plastics products	8.27	7.99	7.64	4.06	344.86	329.19	302.54	164.43

^a For production and nonsupervisory workers in domestic employment. Source: Department of Labor

Productivity rose only moderately . . .



. . . allowing unit labor costs to climb



Note: Productivity is output per workhour, calculated by dividing indexes for production by indexes for workhours of production employees. Unit labor costs are labor costs per unit of output, calculated by dividing indexes for wages by indexes for output per workhour. Sources: Department of Labor, Federal Reserve Board, C&EN calculations

Following a pattern typical for the second year after the end of a recession, chemical productivity improved less in 1984 than in the previous year. In 1983, according to government statistics, production grew nearly 10% at the same time that total workhours decreased 1%, leading to a strong rise in productivity. Last year, by contrast, production of chemicals and allied products increased just 6%, and workhours reversed a two-year decline. The result: Productivity rose 4% compared to 11% in 1983.

Producers of chemicals and allied products were able to hold labor costs in check, nevertheless. Hourly pro-

duction wages jumped 5% in 1984, compared with 6% the year before. Still, because of the smaller gain for productivity, unit labor costs edged up 1%.

Chemical sector productivity fared better than that for all manufacturing, however. With an 11% increase in output and an 8% rise in total workhours, manufacturing productivity was up less than 3% in 1984. On the other hand, wages paid to production workers in manufacturing as a whole were up less—under 4%—than in chemicals and allied products. As a consequence, labor costs per unit of output for all manufacturing increased only a bit more than in the chemical industry.

PRODUCTIVITY: Smaller improvement last year than in 1983

Indexes, 1977 = 100	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
CHEMICALS & ALLIED PRODUCTS											
Production	122.9	115.8	105.6	116.1	111.3	113.3	106.3	100.0	92.0	79.3	85.8
Workhours	96.0	93.9	95.2	101.7	100.9	103.1	102.2	100.0	97.3	92.6	100.9
Productivity	128.0	123.3	110.9	114.2	110.3	109.9	104.0	100.0	94.6	85.6	85.1
Hourly production wages	172.8	164.7	154.9	141.8	129.1	118.2	109.2	100.0	91.9	83.8	75.9
Unit labor costs	135.0	133.6	139.6	124.2	117.1	107.6	105.0	100.0	97.2	97.9	89.2
ALL MANUFACTURING											
Production	119.1	107.1	99.4	108.7	105.9	110.7	106.1	100.0	94.1	84.0	93.5
Workhours	96.0	88.6	87.0	97.9	98.9	106.2	104.5	100.0	96.1	90.4	103.0
Productivity	124.0	120.9	114.3	111.0	107.1	104.2	101.5	100.0	97.9	92.9	90.8
Hourly production wages	161.4	155.5	149.5	140.7	128.0	118.0	108.6	100.0	91.9	85.0	77.8
Unit labor costs	130.2	128.6	130.8	126.7	119.5	113.2	107.0	100.0	93.8	91.5	85.7

Sources: Department of Labor, Federal Reserve Board, C&EN calculations

World chemical trade climbs to new record

World chemical trade, measured as exports, grew an impressive 14% to an estimated \$160 billion last year. That surpasses by a sizable margin the old record of \$147 billion set in 1980. U.S. chemical producers shared in the feast. Their shipments to foreign markets increased 13% to \$22.3 billion.

But it was U.S. imports of chemicals that contributed more than exports to the new trade record. Last year was a rerun of 1983—a healthy U.S. economy acting like a magnet for imports and a too-strong U.S. dollar making it easier for those imports to compete with domestic products.

U.S. chemical imports soared 27% last year—more than twice the rate of gain for exports—to \$13.7 billion. Even on an absolute dollar basis, imports increased more than exports. Largely as a result of the attractive U.S. market, major foreign chemical exporters were able to turn in impressive performances: For Italy, chemical exports were up 25%, West Germany was ahead 18%,

France up almost 20%. It's no surprise, then, that Western Europe, on average, increased chemical shipments to the U.S. 27% to \$6.4 billion.

Other areas got even fatter on the U.S. market. Canada, for instance, raised its exports to the U.S. 31%. And chemical producers in the developing areas of Asia and Latin America also increased exports to the U.S. more than 30%.

As a result, the U.S. chemical trade surplus took another beating in 1984. Following eight successive years of increases, the chemical surplus declined for the fourth year in a row—to \$8.6 billion. That's a 29% slide from its record level of \$12.1 billion in 1980.

Despite all this, the U.S. chemical industry fared better in the trade sweepstakes than U.S. industry overall. With total imports up 26% and exports advancing only an anemic 8%, the U.S. trade deficit exploded from 1983's \$57.5 billion to a worrisome \$108 billion. The gap continues to widen, moreover, so far this year.

U.S. TOTAL TRADE BALANCE: The deficit nearly doubles in 1984

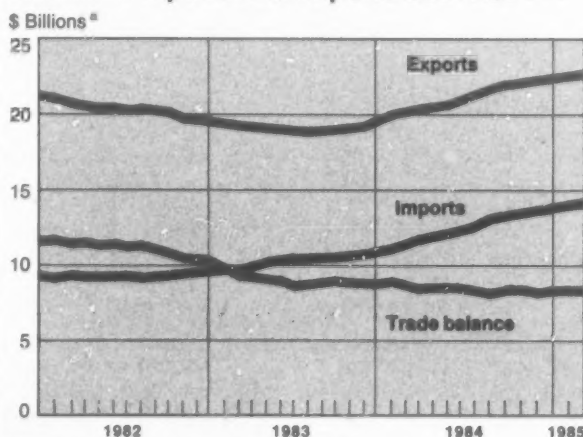
\$ Billions	1984	1983	1982	1974
Total exports	\$217.9	\$200.5	\$212.2	\$ 97.9
Total imports	325.7	258.0	244.0	100.3
Trade balance	-107.8	-57.5	-31.8	-2.4

Source: Department of Commerce

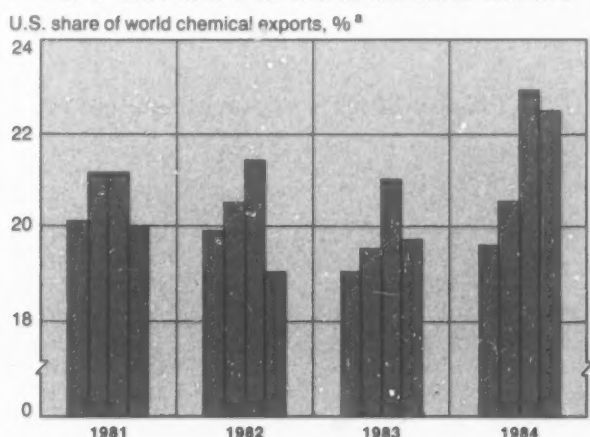
U.S. CHEMICAL TRADE BALANCE: The surplus continues to shrink

\$ Millions	1984	1983	1982	1981
Chemical exports	\$22,336	\$19,751	\$19,891	\$8822
Chemical imports	13,697	10,779	9,494	4018
Trade balance	8,639	8,972	10,397	4804

Chemical exports and imports both rise ...



... and U.S. share of world markets widens



WORLD TRADE: Expansion for chemicals

\$ Millions	1984	1983	1982	1974
CHEMICAL EXPORTS				
World	\$160,000 ^a	\$140,000 ^a	\$135,963	\$63,995
U.S.	22,336	19,751	19,891	8,822
Canada	4,092	3,645	3,406	1,069
EC, 10 countries	83,073 ^a	70,104	67,598	35,830
Belgium-Luxembourg	7,304 ^a	6,216	6,173	3,649
France	14,139 ^a	11,842	11,708	5,434
Italy	7,682 ^a	6,116	5,296	3,127
Netherlands	12,274 ^a	10,536	9,982	5,706
U.K.	12,212 ^a	10,491	10,687	5,027
West Germany	26,207 ^a	22,209	21,185	12,133
Switzerland	5,523	5,539	5,440	2,680
Japan	7,265	6,983	6,365	4,059

CHEMICAL IMPORTS				
U.S.	13,697	10,779	9,494	4,018
Canada	4,023	4,052	3,310	1,857
EC, 10 countries	61,967 ^a	51,382	50,226	23,962
Belgium-Luxembourg	6,293 ^a	5,184	5,143	2,754
France	11,335 ^a	9,533	9,898	4,690
Italy	8,834 ^a	7,307	6,890	3,276
Netherlands	7,061 ^a	5,534	5,473	2,972
U.K.	9,332 ^a	7,764	7,318	3,636
West Germany	14,780 ^a	12,494	12,031	5,201
Switzerland	3,432	3,315	3,208	1,708
Japan	8,346	7,207	6,824	2,668

^a C&EN estimates. Sources: United Nations, Organization for Economic Cooperation & Development, European Communities, individual country agencies

U.S. TRADE: Asia becomes a growth market

\$ Millions	1984	1983	1982	1974
U.S. CHEMICAL EXPORTS				
Canada	\$ 2,752	\$ 2,546	\$ 2,183	\$1213
Western Europe	6,497	5,892	5,940	2665
Eastern Europe	275	306	366	54
Communist Asia	645	353	497	10
Japan	2,961	2,607	2,530	766
Rest of Asia	3,292	2,859	2,600	936
Middle East	429	423	533	181
Latin America	3,827	3,273	3,670	2245
Australasia	842	698	655	351
Africa	510	492	524	270
Other	306	304	393	131
TOTAL	\$22,336	\$19,751	\$19,891	\$8822

U.S. CHEMICAL IMPORTS				
Canada	\$ 3,131	\$ 2,390	\$2,596	\$ 837
Western Europe	6,392	5,020	4,174	1960
Eastern Europe	325	197	151	42
Communist Asia	157	131	136	18
Japan	1,312	1,099	879	486
Rest of Asia	377	283	220	80
Middle East	124	113	99	16
Latin America	1,208	924	613	219
Australasia	251	234	286	196
Africa	196	227	225	26
Other	224	161	115	136
TOTAL	\$13,697	\$10,779	\$9,494	\$4018

Source: Department of Commerce

U.S. TRADE, BY PRODUCTS: All major product categories contribute to surge in exports

\$ Millions	Chemical exports				Chemical imports			
	1984	1983	1982	1974	1984	1983	1982	1974
Organic chemicals	\$ 6,093	\$ 5,326	\$ 5,440	\$2652	\$ 4,265	\$ 3,477	\$2980	\$1373
Inorganic chemicals	2,184	1,838	1,969	836	2,064	1,615	1502	740
Radioactive and associated materials	1,421	1,213	1,132	215	1,394	952	1143	120
Dyeing, tanning, and coloring materials	158	163	162	123	358	300	213	103
Pigments, paints, and varnishes	335	328	332	182	232	145	103	25
Medicinals and pharmaceuticals	2,628	2,494	2,275	800	921	703	563	211
Flavors, perfumes, cosmetics, and toiletries	498	493	514	195	521	370	295	176
Cleaning and polishing materials	308	295	324	175	118	90	76	29
Fertilizers, manufactured	1,815	1,267	1,386	812	1,142	997	963	631
Explosives and pyrotechnics	146	87	90	50	84	64	67	20
Plastics and resins	4,050	3,732	3,650	1618	1,484	1,098	786	327
Pesticides and disinfectants	707	630	607	a	308	251	265	a
Miscellaneous chemical products	1,992	1,885	2,010	1166	797	717	579	253
TOTAL	\$22,336	\$19,751	\$19,891	\$8822	\$13,697	\$10,779	\$9494	\$4018

a Included in miscellaneous chemical products. Source: Department of Commerce

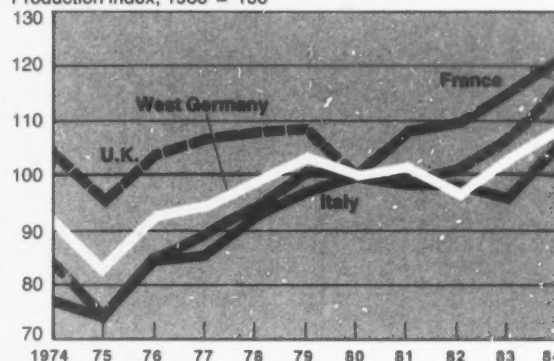
5 Foreign Chemical Industries—Western Europe

Chemical companies throughout Western Europe turned in a good performance last year. Net income, compared with 1983, was up, in some cases by sizable amounts. The most dramatic increase was provided by France's Rhône-Poulenc, but others showing a better than 50% gain were DSM, Norsk Hydro, Solvay, BASF, Laporte, Bayer, Imperial Chemical Industries, and Fisons. Even Montedison, long in the red, managed to just break into the black.

Increases in sales, earnings, and capital outlays aren't immediately evident when viewing the U.S. dollar equivalents of the actual results. The reason is that last year the dollar continued to strengthen against European currencies. Ironically, this strengthening helped boost sales of European products in dollar trading areas and contributed to the improved earnings picture.

Chemical output rose smartly in 1984

Production index, 1980 = 100



CHEMICAL INDUSTRY TRENDS: Output grows but currency translation affects dollar values

\$ Billions (U.S.)	1984	1983	1982	1981	1980
WEST GERMANY					
Sales	\$ 49.5	\$ 49.7	\$ 48.5	\$ 51.6	\$ 59.2
Exports	25.1	24.0	22.9	23.8	26.0
Imports	14.0	13.6	13.0	13.3	14.6
Capital spending	2.5	2.7	2.8	3.1	3.8
Production index ^a	108.8	103.4	96.4	101.6	100.0
Price index ^a	118.1	113.9	113.7	108.7	100.0
Employees (thousands)	550	549	559	548	550
FRANCE					
Sales	\$ 29.1	\$ 30.1	\$ 30.4	\$ 33.4	\$ 37.3
Exports	12.2	11.5	11.2	11.9	13.0
Imports	9.2	8.9	9.1	9.2	10.4
Capital spending	1.0	1.0	1.1	1.2	1.6
Production index ^a	121.2	114.9	110.2	108.8	100.0
Price index ^a	153.1	139.9	128.2	114.2	100.0
Employees (thousands)	279	282	286	289	296
U.K.^b					
Sales	\$ 25.7	\$ 25.6	\$ 28.2	\$ 37.6	\$ 41.0
Exports	11.0	10.5	11.5	12.3	12.3
Imports	8.8	8.1	8.2	7.9	7.3
Capital spending	1.4	1.4	1.9	2.5	3.2
Production index ^a	115.6	108.7	100.8	98.7	100.0
Price index ^a	125.2	119.1	113.5	106.3	100.0
Employees (thousands)	329	330	338	395	430
ITALY					
Sales	\$ 23.3	\$ 22.9	\$ 22.7	\$ 24.1	\$ 28.7
Exports	5.8	5.7	5.0	5.6	5.9
Imports	8.6	7.9	7.4	7.8	9.0
Capital spending	1.0	1.1	1.1	1.1	1.9
Production index ^a	106.2	100.0	98.3	98.1	100.0
Price index ^a	148.2	134.9	124.1	111.9	100.0
Employees (thousands)	241	251	260	271	289
SPAIN					
Sales	\$ 14.8	\$ 14.2	\$ 15.2	\$ 15.7	\$ 17.3
Exports	2.7	2.2	2.2	2.3	2.5
Imports	3.0	2.8	2.9	3.1	3.5
Capital spending	0.2	0.3	0.4	0.4	0.7
Production index ^a	111.0	104.5	100.0	98.3	100.0
Price index ^a	162.1	147.4	131.0	116.9	100.0
Employees (thousands)	241	242	243	244	244

\$ Billions (U.S.)	1984	1983	1982	1981	1980
BELGIUM^{b,c}					
Sales	\$ 13.6	\$ 13.2	\$ 14.1	\$ 15.3	\$ 16.6
Exports ^d	9.2	8.8	8.9	9.2	10.4
Imports ^d	6.6	6.3	6.3	6.4	7.5
Capital spending	0.4	0.4	0.3	0.4	0.5
Production index ^a	114.9	107.3	103.1	101.1	100.0
Price index ^a	139.9	133.7	126.0	110.7	100.0
Employees (thousands)	89	88	98	88	90
NETHERLANDS					
Sales	\$ 13.5	\$ 13.1	\$ 12.5	\$ 13.6	\$ 14.3
Exports	12.5	12.0	11.3	11.9	13.0
Imports	7.2	6.8	6.7	7.1	7.9
Capital spending	0.8	0.7	0.6	0.6	0.7
Production index ^a	119.0	111.0	100.0	97.7	100.0
Price index ^a	124.2	115.0	114.0	114.4	100.0
Employees (thousands)	89	88	90	91	91
SWITZERLAND					
Sales	\$ 6.5	\$ 6.7	\$ 6.6	\$ 6.7	\$ 6.8
Exports	5.4	5.5	5.4	5.4	5.6
Imports	3.4	3.3	3.3	3.3	3.7
Production index ^a	115.7	109.6	103.0	104.2	100.0
Price index ^a	109.1	106.4	106.8	104.9	100.0
Employees (thousands)	68	68	na	63	62
SWEDEN					
Sales	\$ 4.1	\$ 3.9	\$ 4.0	\$ 4.1	\$ 4.3
Exports	1.9	1.8	1.6	1.6	1.7
Imports	2.7	2.7	2.6	2.5	2.9
Capital spending	0.3	0.3	0.3	0.3	0.4
Production index ^a	116.9	113.2	104.8	109.4	100.0
Price index ^a	147.0	135.5	120.4	108.8	100.0
Employees (thousands)	43	43	44	41	39
NORWAY					
Sales	\$ 2.2	\$ 2.1	\$ 2.0	\$ 1.9	\$ 2.1
Exports	1.2	1.1	1.0	1.5	1.2
Imports	1.0	0.9	0.9	1.0	1.1
Capital spending	0.1	0.1	0.1	0.1	0.2
Production index ^a	118.0	110.0	100.6	101.7	100.0
Price index ^a	128.1	123.6	117.9	112.5	100.0
Employees (thousands)	17	17	18	17	17

a (1980 = 100). b Excludes fibers. c Includes rubber and plastics processing. d Includes Luxembourg. Sources: National agencies and European Council of Chemical Manufacturers' Federations (CECIC)

MAN-MADE FIBERS: Noncellulosics continue recovery from 1982 slump

	1984		1983		1982		1981		1980		Change, 1983-84	
Millions of lb	Non-cellulosics ^a	Cellulosics	Non-cellulosics ^a	Cellulosics	Non-cellulosics ^a	Cellulosics	Non-cellulosics ^a	Cellulosics	Non-cellulosics ^a	Cellulosics	Non-cellulosics ^a	Cellulosics
West Germany	1696	359	1654	334	1511	315	1735	322	1619	304	3%	7%
Italy	1324 ^b	68	1166 ^b	65	1091 ^b	102	1115 ^b	133	896 ^b	144	14	5
Spain	578	73	539	70	507	95	526	111	452	116	7	4
U.K.	559 ^c	305 ^d	541 ^c	330 ^d	506 ^c	263 ^d	612 ^c	298 ^d	700 ^c	364 ^d	3	-8
France	452	61	437	83	435	100	444	119	423	146	3	-27
Switzerland	218	0	204	0	183	0	197	0	186	4	7	—
Benelux countries	206	94	189	90	198	124	229	144	230	148	9	4
Ireland	130	0	118	0	114	0	111	0	92	0	10	—
Portugal	106	0	95	1	99	3	83	7	67	6	12	-100
Austria	53	268	53	251	51	251	53	257	56	255	0	7

a Excludes polypropylene. b Includes polypropylene filament. c Includes cellulose acetate filament. d Excludes cellulose acetate filament. Source: Comité International de la Rayonne et des Fibres Synthétiques

PRODUCTION: Higher last year for the majority of major chemicals

Millions of lb	1984	1983	1982	1981	Change 1983-84
FRANCE					
Sulfuric acid	9898	9024	8858	9917	10%
Hydrochloric acid	1686	1483	1514	1544	14
Chlorine	3103	2872	2759	2711	8
Sodium hydroxide	3274	3064	2939	2893	7
Ammonia	5170	4312	4180	4950	20
Benzene	1343	1373	1133	1100	-2
Toluene	87	90	69	124	-3
Xylenes	188	199	113	251	-6
Ethylene	4581	4563	4112	4085	0
Propylene	2652	2455	2277	2212	8
Butadiene	667	620	569	586	8
Formaldehyde	210	208	175	220	1
Methanol	697	761	753	765	-8
Polyethylenes	2045	2070	1938	1944	-1
Polypropylene	871	842	692	656	3
Polystyrene	1060	1056	972	851	0
Polyvinyl chloride	1737	1796	1729	1563	-3
Synthetic rubber	1218	1125	1045	1070	8
Phosphate fertilizers (P ₂ O ₅)	1495	1577	2447	2590	-5
ITALY					
Sulfuric acid	9370	9071	8818	7861	3%
Nitric acid	2420	2261	2247	2212	7
Phosphoric acid	996	999	970	979	0
Chlorine	2095	1974	1701	1556	6
Sodium hydroxide	2359	2219	1999	1857	6
Ammonia	3233	2494	2804	3239	30
Benzene	1179	1160	841	932	2
Toluene	688	658	580	613	5
Xylenes	871	804	594	564	8
Ethylene	2504	2337	1923	2011	7
Propylene	1244	1143	981	1083	9
Butadiene	399	380	345	366	5
Phthalic anhydride	213	298	298	309	-29
Formaldehyde	325	312	275	240	4
Acetic acid	140	237	342	401	-41
Carbon black	380	339	334	337	12
Polyethylenes	1602	1564	1167	1223	2
Polystyrene	695	725	674	637	-4
Polyvinyl chloride	1493	1391	1302	1292	7
Synthetic rubber	514	504	475	535	2

Millions of lb	1984	1983	1982	1981	Change 1983-84
U.K.					
Sulfuric acid	5829	5692	5692	6360	2%
Hydrochloric acid ^a	352	286	260	257	23
Nitric acid	na	6890	6784	6541	—
Chlorine	2158	1980	1935	1916	9
Benzene	1773	1745	1399	1799	2
Ethylene	2541	2913	2454	2718	-13
Propylene	2147	1830	1695	1621	17
Butadiene	570	523	503	457	9
Acetone	355	268	298	245	32
Formaldehyde	228	228	236	249	0
Phenol	406	315	308	241	29
Polyethylenes	875	896	937	1000	-2
Polypropylene	570	506	487	435	13
Synthetic rubber	625	571	537	493	9
WEST GERMANY					
Sulfuric acid	8002	8009	8334	9018	0%
Hydrochloric acid	2104	1980	1865	1953	6
Nitric acid	6287	5778	5040	6356	9
Chlorine	7536	6900	6253	6629	9
Sodium hydroxide	7395	6830	6318	6687	8
Sodium carbonate	3009	2679	2432	2616	12
Sodium sulfate	282	275	472	561	3
Ammonia	5183	4495	4145	5179	15
Benzene	3163	2939	2258	2027	8
Toluene	789	691	590	578	14
Xylenes	1003	1127	1012	1071	-11
Ethylene	7093	6980	5808	6357	2
Propylene	3969	3793	3259	3550	5
Butadiene	1661	1580	1275	na	5
Ethylene oxide	1044	993	866	955	5
Ethylene glycol	509	450	404	487	13
Propylene glycol	372	351	279	263	6
n-Butanol	589	562	508	505	5
Acetaldehyde	737	647	571	670	14
Acetic acid	668	590	562	646	13
Ethanol	120	171	220	222	-30
Formaldehyde	1283	1175	1070	1117	9
Methanol	1504	1470	1559	1524	2
Phthalic anhydride	453	429	439	474	6
Polyethylenes	2882	2996	2473	2639	-4
Polyvinyl chloride	2490	2398	1902	2021	4
Synthetic rubber	988	951	888	914	4
Nitrogen fertilizers (N)	1843	1642	1464	2191	12
Phosphate fertilizers (P ₂ O ₅)	473	552	595	732	-14

a Manufacturers' sales. na = not available. Sources: Government agencies for each country

5 Foreign Chemical Industries—Western Europe

COMPANY RESULTS: With profitability improving, many firms hiked capital and R&D budgets

\$ Millions	Net sales	Net income	Profit margin	Capital spending	R&D spending	Employees (thousands)	\$ Millions	Net sales	Net income	Profit margin	Capital spending	R&D spending	Employees (thousands)
Bayer (West Germany)							Norsk Hydro (Norway)						
1984	\$15,098.9	\$411.9	2.7%	\$ 646.3	\$686.3	174.8	1984	\$4,357.5	\$130.5	3.0%	\$596.4	na	19.8
1983	14,641.6	295.7	2.0	734.1	664.3	174.8	1983	4,077.9	66.8	1.6	593.0	na	18.8
1982	14,335.0	26.3	0.2	846.6	637.9	179.4	1982	3,185.9	24.2	0.8	509.3	na	19.6
1981	14,930.1	228.8	1.5	1123.5	622.1	180.9	1981	3,045.6	65.0	2.1	370.7	na	15.1
Hoechst (West Germany)							Solvay (Belgium)						
1984	\$14,546.3	\$474.4	3.3%	\$724.9	\$637.9	177.9	1984	\$3,883.9	\$200.2 ⁱ	5.2%	\$179.9	\$126.7	43.5
1983	14,583.9	356.5	2.4	733.3	634.1	179.8	1983	3,887.0	128.3 ^m	3.3	155.3	127.1	44.2
1982	14,397.5	130.5	0.9	850.6	642.4	182.2	1982	3,891.3	47.6 ⁿ	1.2	153.8	131.1	45.4
1981	15,236.7	188.5	1.2	870.4	670.4	184.7	1981	4,239.7	(9.9) ^o	—	247.6	143.4	48.2
BASF (West Germany)							Hoffmann-La Roche (Switzerland)						
1984	\$14,175.4	\$314.0	2.2%	\$719.6	\$435.8	115.8	1984	\$3,519.1	\$161.8	4.6%	\$194.0	\$486.4	46.2
1983	13,769.0	202.7	1.5	639.2	466.3	114.1	1983	3,576.2	156.4	4.4	216.1	473.5	45.9
1982	13,368.7	113.2	0.8	824.3	483.1	115.9	1982	3,499.2	138.5	4.0	346.7	453.5	46.5
1981	14,055.8	162.4	1.2	911.1	484.1	116.6	1981	3,456.4	129.1	3.7	308.6	414.2	44.0
Imperial Chemical Industries (U.K.)							Sandoz (Switzerland)						
1984	\$13,247.3	\$806.8 ^a	6.1%	\$589.6	\$399.7	115.6	1984	\$3,163.4	\$174.9	5.5%	\$129.4	\$269.8	38.0
1983	12,528.1	602.4 ^b	4.8	547.8	418.8	117.9	1983	3,117.1	152.4	4.9	128.8	261.9	38.1
1982	12,886.2	253.9	2.0	511.4	427.3	123.8	1982	2,981.8	134.5	4.5	124.6	244.8	37.3
1981	13,348.9	389.5 ^c	2.9	833.7	464.5	132.4	1981	2,941.8	115.8	3.9	155.6	236.2	36.4
Ciba-Geigy (Switzerland)							BOC International (U.K.)						
1984	\$7,435.7	\$505.1	6.8%	\$428.5	\$619.6	81.4	1984	\$2,811.5	\$106.0 ^p	3.8%	\$322.6	\$56.6	38.7
1983	7,019.5	369.5	5.3	395.2	594.3	79.2	1983	2,582.1	83.2 ^q	3.2	468.1	40.8	39.1
1982	6,802.0	306.4	4.5	427.6	578.8	79.4	1982	2,686.9	113.0 ^r	4.2	388.3	43.6	38.4
1981	6,938.3	265.8	3.8	446.4	549.0	80.2	1981	3,086.6	93.9 ^s	3.0	316.0	38.9	42.1
Montedison (Italy)							Albright & Wilson (U.K.)						
1984	\$7,047.2	\$ 2.8 ^t	0.0%	\$279.5	\$142.3	71.2	1984	\$ 761.2	\$29.3 ^u	3.8%	\$46.8	na	6.3
1983	7,017.8	(207.4) ^v	—	295.6	171.2	72.8	1983	865.3	31.9 ^v	3.7	37.2	na	6.3
1982	6,665.9	(529.9) ^w	—	324.5	170.7	84.2	1982	929.6	12.4 ^w	1.3	33.6	na	7.2
1981	7,851.3	(564.6) ^x	—	377.3	175.0	94.2	1981	1,019.9	9.3 ^w	0.9	51.7	na	8.9
DSM (Netherlands)							Fisons (U.K.)						
1984	\$7,018.7	\$144.2	2.1%	\$285.7	\$54.5	27.2	1984	\$ 738.8	\$50.8 ^x	6.9%	\$9.4	\$20.1	8.6
1983	6,969.8	57.5	0.8	230.9	61.4	27.9	1983	554.5	38.1 ^y	6.9	4.7	21.2	7.5
1982	6,806.0	(70.3) ^z	—	165.5	63.7	28.6	1982	613.8	25.4	4.1	3.2	29.4	7.5
1981	7,330.4	40.4	0.6	196.8	64.0	30.0	1981	1,002.8	7.8	0.8	3.9	31.2	9.8
Rhône-Poulenc (France)							UCB (Belgium)						
1984	\$5,858.4	\$227.6	3.9%	\$395.2	\$281.7	80.0	1984	\$534.8	\$22.9 ^z	4.3%	\$21.6	\$18.4	6.5
1983	5,658.4	12.9	0.2	365.4	286.0	80.8	1983	572.4	22.0 ^{aa}	3.8	23.5	17.6	6.4
1982	5,661.5	(128.5) ^{ab}	—	329.7	267.6	81.8	1982	606.6	9.4	1.6	20.0	17.2	6.7
1981	6,604.6	(61.6) ^{ac}	—	447.8	279.8	89.3	1981	686.0	4.3	0.6	31.0	18.7	7.8
Akzo (Netherlands)							Laporte Industries (U.K.)						
1984	\$5,146.4	\$252.0 ^b	4.9%	\$244.2	\$198.8	66.1	1984	\$475.4	\$38.5 ^{bb}	8.1%	\$13.5	na	3.6
1983	5,293.0	189.1 ^d	3.6	219.3	217.5	66.3	1983	440.4	27.7 ^{cc}	6.3	7.7	na	3.5
1982	5,301.1	85.0 ^e	1.6	273.4	232.2	73.7	1982	425.5	19.3 ^{dd}	4.6	21.7	na	3.5
1981	5,790.4	95.6 ^e	1.6	277.2	234.0	77.8	1981	435.5	12.6	2.9	20.3	na	3.9

a Excludes nonrecurring loss of \$26.7 million. b Excludes nonrecurring loss of \$28.8 million. c Excludes nonrecurring loss of \$12.2 million. d Excludes profits to minority interests of \$50.1 million. e Deficit. f Excludes minority interests' loss of \$4.6 million. g Excludes nonrecurring loss of \$105.7 million and gain from minority interests of \$0.7 million. h Excludes nonrecurring loss of \$10.9 million. i Excludes nonrecurring loss of \$35.8 million. j Excludes nonrecurring gain of \$18.4 million. k Excludes nonrecurring gain of \$2.8 million. l Excludes nonrecurring loss of \$60.9 million. m Excludes nonrecurring loss of \$25.7 million. n Excludes nonrecurring gain of \$9.2 million. o Excludes nonrecurring loss of \$10.3 million. p Excludes extraordinary gain of \$16.7 million. q Excludes nonrecurring loss of \$19.4 million. r Excludes nonrecurring gain of \$10.7 million. s Excludes nonrecurring gain of \$1.2 million. t Excludes nonrecurring loss of \$267,000. u Excludes nonrecurring gain of \$1.5 million. v Excludes nonrecurring loss of \$17.2 million. w Excludes nonrecurring gain of \$1.8 million. x Excludes nonrecurring loss of \$5.6 million. y Excludes nonrecurring loss of \$10.0 million. z Excludes extraordinary gain of \$743,000. aa Excludes nonrecurring loss of \$3.0 million. bb Excludes extraordinary gain of \$57.8 million. cc Excludes nonrecurring loss of \$3.5 million. dd Excludes nonrecurring gain of \$138.4 million. na = not available.

NOTE ON CURRENCY CONVERSION

For monetary statistics in this section, European currencies were converted to U.S. dollars by the following conversion rates:

	Belgium	France	Italy	Netherlands	Norway	Spain	Sweden	Switzerland	U.K.	West Germany
1984	57.78 francs	8.74 francs	1757 lire	3.21 guilders	8.16 crowns	160.76 pesetas	8.27 crowns	2.35 francs	0.748 pound	2.85 marks
1983	51.13 francs	7.62 francs	1519 lire	2.85 guilders	7.30 crowns	143.43 pesetas	7.67 crowns	2.10 francs	0.659 pound	2.55 marks
1982	45.69 francs	6.57 francs	1353 lire	2.67 guilders	6.45 crowns	109.86 pesetas	6.28 crowns	2.03 francs	0.571 pound	2.43 marks
1981	37.13 francs	5.44 francs	1137 lire	2.50 guilders	5.74 crowns	92.31 pesetas	5.06 crowns	1.96 francs	0.493 pound	2.26 marks
1980	29.24 francs	4.23 francs	856 lire	1.99 guilders	4.94 crowns	71.71 pesetas	4.23 crowns	1.67 francs	0.430 pound	1.82 marks

1984 was a year of recovery for the Japanese chemical industry. For many chemicals and plastics, production set new records. More important, profits of many chemical companies staged a comeback.

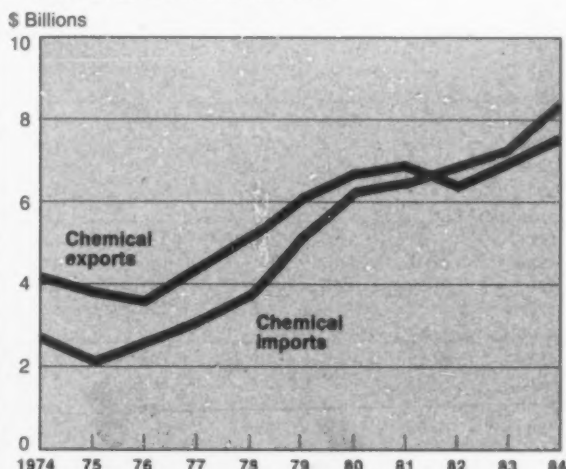
The chemical industry production index was up a respectable 8.5% last year. Even the petrochemical sector, long troubled by international competition, pushed output ahead 16%. If there was a weak spot, it was in chemical trade. Japanese chemical exports advanced 9% to \$7.6 billion, but imports increased 16% to \$8.3 billion. The resulting \$721 million deficit was triple that of 1983. This weakness is a not-so-subtle clue that Japan's chemical industry may be hard-pressed to repeat last year's stellar performance.

PRODUCTION: Organics, polymers set pace

Production Indexes, 1980 = 100	1984	1983	1982	1981	Change 1983-84
All chemicals	118.0	108.8	102.5	99.8	8%
All manufacturing	116.7	104.9	101.4	101.0	11
Inorganic chemicals and pigments	105.6	101.7	95.7	98.7	4
Alkalies and chlorine	95.2	90.7	90.1	91.3	5
Organic chemicals	96.9	86.6	86.5	89.2	12
Petrochemicals	113.8	98.5	92.4	94.5	16
Aromatics	106.6	96.1	90.7	94.4	11
Cyclic intermediates and dyes	116.9	105.1	97.5	98.3	11
Plastics	119.7	105.2	96.5	95.4	14
Synthetic fibers	100.2	97.1	96.0	97.9	3
Synthetic rubber	106.1	91.6	85.1	92.3	16
Fertilizer	79.8	77.4	80.2	84.6	3
Textile materials	108.0	98.6	97.0	99.7	10
Medicinals and drugs	135.2	126.9	116.8	107.8	7

Source: Ministry of International Trade & Industry

Exports increase but trade gap in chemicals widens further



Source: Ministry of International Trade & Industry

PRODUCTION: Plastics lead the recovery

Thousands of metric tons unless otherwise indicated	1984	1983	1982	1981	Change 1983-84
ORGANIC CHEMICALS					
Acetaldehyde	297	255	279	324	16%
Acetic acid	350	328	353	365	7
Acetone	246	247	229	225	0
Acrylonitrile	523	459	489	477	14
Benzene	2013	1750	1588	1690	15
Butadiene	657	556	522	518	18
Butyl alcohol	243	229	228	237	6
Caprolactam	436	395	388	427	10
Cyclohexane	492	454	426	475	8
Diethylphthalate	249	231	221	223	8
Ethylene	4384	3684	3590	3655	19
Ethylene dichloride	1939	1736	1548	1650	12
Ethylene glycol	429	357	385	411	20
Ethylene oxide	533	468	471	478	14
Methanol, refined	280	373	625	734	-25
Octyl alcohol, synthetic	246	219	226	239	12
Phenol, synthetic	272	271	211	214	0
Phthalic anhydride	156	161	159	164	-3
Propylene	2959	2632	2565	2538	11
Propylene glycol	205	194	185	171	6
Styrene	1421	1167	1086	1095	22
Terephthalic acid	745	702	649	635	6
Toluene	784	831	803	821	-6
Toluene diisocyanate	76	74	67	64	3
Urea	1401	1264	1225	1483	11
Xylene	1120	980	1187	1202	14

INORGANIC CHEMICALS

Ammonia	2029	1881	2010	2228	8
Ammonium chloride	387	435	486	584	8
Ammonium sulfate	1829	1722	1689	1817	6
Calcium carbide	478	476	483	495	0
Calcium superphosphate	559	559	527	483	0
Carbon black	602	568	504	557	6
Chlorine, liquid	897	818	794	764	10
Hydrochloric acid	521	511	551	565	2
Nitrogen, millions of cu m	5896	5369	5236	5147	10
Oxygen, millions of cu m	7216	6434	6493	6603	12
Sodium carbonate	1036	1103	1162	1178	-6
Sodium hydroxide	3085	2863	2792	2872	8
Sodium silicate	596	588	650	692	1
Sulfuric acid	6458	6662	6530	6572	3
Titanium dioxide	205	196	184	176	5

PLASTICS

Phenolic resins	334	303	281	294	10
Polyethylene	2251	1773	1674	1671	27
Polypropylene	1271	1062	941	959	20
Polystyrene	1503	1311	1190	1183	15
Polyvinyl chloride	1504	1420	1218	1129	6

DYES, synthetic 57 55 54 50 4

RUBBER CHEMICALS, organic 45 42 39 43 7

RUBBER, synthetic 1130 1002 931 1010 16

Source: Ministry of International Trade & Industry

5 Foreign Chemical Industries—Japan

COMPANY RESULTS: Profitability improved modestly last year for most chemical firms

\$ Millions	Sales	Net income	Profit margin	Total assets	Employees (thousands)
Mitsubishi Chemical Industries^a					
1984	\$3271	\$ 0.0	—	\$3211	8.3
1983	3155	0.6	0.0%	3479	8.5
1982	3142	(36.5) ^b	—	3326	8.4
1981	3399	13.5	0.4	3374	8.3
Asahi Chemical Industry					
1984	\$3168	\$57.2	1.8%	\$3027	15.9
1983	2985	47.0	1.6	3022	16.3
1982	2670	45.8	1.7	2809	14.0
1981	2663	48.4	1.8	2895	13.6
Sumitomo Chemical^c					
1984	\$2862	\$73.6	2.6%	\$2818	6.9
1983	2783	17.3	0.6	2775	7.9
1982	2681	(30.6) ^b	—	2510	9.1
1981	2881	10.5	0.4	2699	9.6
Toray Industries					
1984	\$2617	\$55.2	2.1%	\$2663	13.2
1983	2588	66.0	2.6	2576	14.1
1982	2398	59.4	2.5	2385	13.9
1981	2503	48.3	1.9	2446	13.9
Teijin					
1984	\$1758	\$53.2	3.0%	\$1842	7.2
1983	1797	51.4	2.9	1846	7.1
1982	1751	30.1	1.7	1953	7.1
1981	2072	24.1	1.2	2090	7.2
Dainippon Ink & Chemicals					
1984	\$1676	\$20.4	1.2%	\$1449	6.0
1983	1681	19.0	1.1	1472	6.0
1982	1609	17.9	1.1	1426	5.9
1981	1657	18.8	1.1	1511	5.9
Showa Denko^c					
1984	\$1656	\$ 0.0	—	\$2069	4.6
1983	1500	(6.6) ^b	—	2086	5.0
1982	1539	(2.9) ^b	—	2004	5.3
1981	1729	2.6	0.2%	2102	5.4
Mitsui Toatsu Chemicals					
1984	\$1635	\$ 10.2	0.6%	\$1810	5.3
1983	1695	(14.7) ^b	—	1794	5.4
1982	1783	44.9	2.5	1790	5.7
1981	1948	(22.3) ^b	—	1858	7.4
Mitsubishi Petrochemical^c					
1984	\$1594	\$ 40.9	2.6%	\$1553	2.3
1983	1547	2.0	0.1	1644	2.5
1982	1508	(37.4) ^b	—	1767	3.5
1981	1667	(6.3) ^b	—	1802	3.9
Sekisui Chemical					
1984	\$1431	\$18.4	1.3%	\$1184	6.1
1983	1369	15.7	1.2	1199	6.1
1982	1294	9.0	0.7	1238	6.2
1981	1338	7.9	0.6	1322	6.1
Mitsui Petrochemical Industries					
1984	\$1226	\$24.5	2.0%	\$1413	4.3
1983	1227	16.1	1.3	1392	4.3
1982	1200	(7.1) ^b	—	1412	4.5
1981	1260	(8.6) ^b	—	1455	4.6
Unitika					
1984	\$1165	\$ 6.5	0.6%	\$1111	5.5
1983	1192	0.6	0.1	1146	6.4
1982	1045	(18.6) ^b	—	1113	6.2
1981	965	0.4	0.0	1135	6.2

\$ Millions	Sales	Net income	Profit margin	Total assets	Employees (thousands)
Mitsubishi Gas Chemical					
1984	\$1014	\$20.0	2.0%	\$944	3.7
1983	937	12.9	1.4	891	3.8
1982	909	9.9	1.1	884	3.8
1981	931	20.8	2.2	938	3.8
Shin Etsu Chemical^d					
1984	\$961	\$32.3	3.4%	\$695	2.6
1983	871	32.8	3.8	609	2.5
1982	668	18.4	2.8	601	2.5
1981	674	8.5	1.3	629	2.4
Hitachi Chemical					
1984	\$932	\$14.7	1.6%	\$571	4.8
1983	849	11.1	1.3	489	4.5
1982	751	8.5	1.1	465	4.4
1981	753	9.9	1.3	451	4.3
Kyowa Hakko Kogyo^c					
1984	\$920	\$22.1	2.4%	\$888	5.4
1983	929	21.2	2.3	836	5.1
1982	915	21.0	2.3	802	5.0
1981	928	18.8	2.0	782	4.9
Mitsubishi Rayon					
1984	\$920	\$18.4	2.0%	\$869	3.8
1983	912	13.1	1.4	884	3.7
1982	841	9.9	1.2	824	3.6
1981	894	11.0	1.2	803	3.5
Toyo Soda Mfg.					
1984	\$920	\$ 28.6	3.1%	\$1233	3.8
1983	948	29.0	3.1	1133	3.9
1982	883	(10.7) ^b	—	1131	4.3
1981	927	(60.4) ^b	—	1209	4.9
Denki Kagaku Kogyo					
1984	\$879	\$ 28.6	3.3%	\$1117	4.0
1983	874	(15.2) ^b	—	1112	4.0
1982	797	8.5	1.1	1091	4.0
1981	867	10.4	1.2	1092	4.0
Kuraray					
1984	\$859	\$7.0	0.8%	\$951	6.0
1983	869	5.3	0.6	943	6.4
1982	821	4.3	0.5	904	6.3
1981	879	8.2	0.9	928	6.3
Japan Synthetic Rubber					
1984	\$838	\$13.5	1.6%	\$775	2.7
1983	783	18.0	2.3	678	2.7
1982	699	7.5	1.1	709	2.7
1981	737	3.0	0.4	720	2.7
Kanagafuchi Chemical Industry					
1984	\$818	\$22.5	2.8%	\$622	2.9
1983	778	9.9	1.3	597	2.9
1982	673	8.3	1.2	546	3.3
1981	719	5.9	0.8	583	3.2
Daicel Chemical					
1984	\$720	\$20.0	2.8%	\$687	3.1
1983	697	17.2	2.5	643	3.1
1982	654	12.9	2.0	634	3.1
1981	702	12.5	1.8	656	3.1
Tokuyama Soda					
1984	\$695	\$8.2	1.2%	\$748	2.3
1983	695	4.5	0.7	691	2.4
1982	695	5.5	0.8	669	2.5
1981	768	4.4	0.6	691	2.5

a Fiscal year ends Jan. 31. b Deficit. c Fiscal year ends Dec. 31. d Fiscal year ends May 31. Note: Fiscal years end March 31 for each year unless otherwise indicated. Fiscal year 1984 data are estimates. Results are converted from yen to U.S. dollars on the following basis: Fiscal year 1984: \$1.00 = 244.6 Y; fiscal year 1983: \$1.00 = 236.7 Y; fiscal year 1982: \$1.00 = 235.8 Y; fiscal year 1981: \$1.00 = 222.4 Y. Year-to-year changes in sales, net income, and assets are affected by fluctuations in the currency exchange rate. Source: Toyo Keizai Shinposha

5 Foreign Chemical Industries—Canada

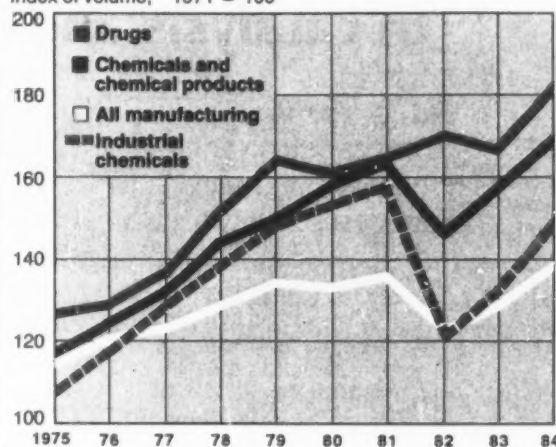
With several new world-scale plants coming on stream last year, the Canadian chemical industry chalked up sizable gains in production of many key chemicals, particularly olefins and their derivatives. Output of several large-volume inorganic chemicals scored substantial increases, as well. The aromatics, however, did not fare so well.

Nevertheless, 1984 has to be scored a good year for Canadian chemicals. For most companies, sales, net incomes, and profit margins all increased. What pressure there was on profits fell mainly in the petrochemical sector, where high feedstock costs—the result of government energy-pricing policies and up-front taxes—eroded competitiveness of Canadian products against foreign petrochemicals.

Despite this, Canadian chemical companies boosted exports 22% to \$5.3 billion. And because chemical imports grew only 19% (to \$5.2 billion), Canada was able to swing its chemical trade balance marginally back into the black from the previous year's small deficit.

Output bounces back from 1982 low

Index of volume, 1971 = 100



■ Gross domestic product. Source: Statistics Canada

COMPANY RESULTS: Earnings increase

\$ Millions (Canadian)	Sales	Net income ^a	Profit margin	Capital expenditures	Employees (thousands)
C-I-L Inc.					
1984	\$1176.0	\$38.0	3.2%	\$118.3	6.3
1983	1113.8	23.9	2.1	109.0	6.7
1982	1059.8	15.2	1.4	85.5	6.9
1981	1149.9	54.3	4.7	94.1	7.8
Celanese Canada					
1984	\$387.4	\$ 7.8	2.0%	\$13.3	2.8
1983	378.8	9.4	2.5	12.0	3.4
1982	305.5	(5.2) ^b	—	54.0	3.4
1981	354.1	20.7	5.9	85.5	3.5
Du Pont Canada					
1984	\$1170.6	\$41.2	3.5%	\$45.2	5.0
1983	1116.4	35.2	3.2	25.2	5.0
1982	980.0	(7.4) ^b	—	23.9	5.4
1981	1139.1	33.5	2.9	47.2	6.1
Polysar					
1984	\$1416.2	\$ 35.9	2.5%	\$ 57.2	6.0
1983	1336.9	8.7	0.7	144.2	6.0
1982	1330.0	(30.5) ^b	—	207.0	6.6
1981	1049.0	74.0	7.1	58.3	5.4
Union Carbide Canada					
1984	\$691.4	\$ 5.7	0.8%	\$ 26.6	4.1
1983	687.0	(1.4) ^b	—	55.9	4.2
1982	691.3	(17.9) ^b	—	67.6 ^c	4.5
1981	827.3	36.1	4.4	100.0	5.0

^a Excluding extraordinary gains and losses. ^b Deficit. ^c Excludes \$50.9 million spent on Prentiss, Alta., ethylene glycol plant that was transferred to another Union Carbide subsidiary.

PRODUCTION: Plastics, fertilizers set the pace

Thousands of metric tons	1984	1983	1982	1981	Change 1983-84
ORGANIC CHEMICALS					
Benzene	557	580	519	571	4%
Butadiene	138	133	118	126	3
Butylene	129	138	107	124	-6
Ethylene	1464	1196	1013	1330	22
Formaldehyde	92	90	70	85	2
Methanol	1872	1671	na	na	12
Propanol	63	63	67	73	0
Propylene	665	644	693	671	3
Toluene	430	411	471	480	5
Urea	2110	1445	1231	1303	46
Xylene	417	426	431	409	-2
INORGANIC CHEMICALS					
Ammonia, anhydrous 100%	3493	2889	2509	2654	21
Ammonium nitrate	969	934	1018	1212	4
Ammonium phosphate	1383	1259	1027	1355	10
Chlorine	1424	1385	1233	1292	3
Hydrochloric acid	161	160	143	186	1
Nitric acid	1100	1061	977	1158	4
Phosphoric acid, 100% P ₂ O ₅	691	656	553	744	5
Sodium chlorate	313	294	264	255	6
Sodium hydroxide	1575	1528	1367	1458	3
Sulfuric acid	4053	3686	3131	4117	10
SYNTHETIC RESINS					
Polyesters, unsaturated	34	26	27	26	27
Polyethylene, high density	227	211	194	222	7
Polyethylene, low density	529	412	376	410	28
Polyvinyl chloride	252	243	193	222	4

na = not available. Source: Statistics Canada

SHIPMENTS: A good year for chemical products nearly across the board

\$ Millions (Canadian)	1984	1983	1982	1981	1980	Change 1983-84
All manufacturing	\$225,817	\$199,561	\$183,433	\$190,685	\$168,365	13%
Chemicals and chemical products	15,475	14,371	12,774	13,189	11,218	8
Industrial chemicals, inorganic	2,536	2,325	2,231	2,192	1,856	9
Industrial chemicals, organic	3,175	3,153	2,768	3,202	2,643	1
Plastics and synthetic resins	1,615	1,503	1,286	1,512	1,372	7
Pharmaceuticals and medicinals	2,087	1,785	1,560	1,327	1,144	17
Fertilizers, mixed	255	224	208	218	189	14
Paint and varnish	1,103	1,009	835	880	747	9
Soap and cleaning compounds	1,311	1,197	1,053	1,020	866	10
Toilet preparations	768	711	611	589	504	8
Pigments and dry colors	325	290	260	252	221	12
Printing ink	231	207	193	189	169	12
Miscellaneous chemical products	2,069	1,968	1,768	1,810	1,508	5
Man-made fibers	1,418	1,414	1,164	1,400	1,270	0

Source: Statistics Canada

CHEMICAL IMPORTS: Big jump last year

\$ Millions (Canadian)	1984	1983	1982	Change 1983-84
Inorganic chemicals	\$ 498	\$ 411	\$ 370	21%
Organic chemicals	1464	1200	1019	16
Fertilizers and fertilizer materials	206	184	143	12
Synthetic and reclaimed rubber	207	160	139	29
Plastics materials	842	751	553	12
Plastic film and sheet	331	268	208	24
Other plastic shapes and forms	264	181	137	46
Dyes, except dyeing intermediates	73	77	63	--5
Pigments, lakes, and toners	100	81	52	23
Paints and related products	148	111	85	33
Other chemical products	1077	900	818	20
TOTAL	\$5210	\$4392	\$3586	19%
Imports from U.S.	\$4070	\$3425	\$2796	19%
U.S. share, %	78%	78%	78%	—

Source: Statistics Canada

CHEMICAL EXPORTS: Up more than imports

\$ Millions (Canadian)	1984	1983	1982	Change 1983-84
Chemical elements	\$ 228	\$ 187	\$ 170	22%
Other inorganic chemicals	1040	785	826	32
Organic chemicals	1296	1201	1098	8
Fertilizers and fertilizer materials	1530	1160	1022	32
Synthetic rubber and plastic materials	629	521	516	21
Plastics, basic shapes and forms	266	198	174	34
Other chemical products	309	285	229	8
TOTAL	\$5299	\$4337	\$4035	23%
Exports to U.S.	\$3481	\$2843	\$2528	22%
U.S. share, %	66%	66%	63%	—

Source: Statistics Canada

TRADE BALANCE: Growth for total surplus

\$ Millions (Canadian)	1984	1983	1982	1981
Total exports	\$109,543	\$88,506	\$81,825	\$81,337
Total imports	95,754	75,587	67,856	79,482
Trade balance	13,789	12,919	13,969	1,855

Chemical trade balance barely back in black

Chemical exports	\$ 5,299	\$ 4,337	\$ 4,035	\$ 4,605
Chemical imports	5,210	4,392	3,586	3,814
Chemical trade balance	89	-55	449	791

Source: Statistics Canada

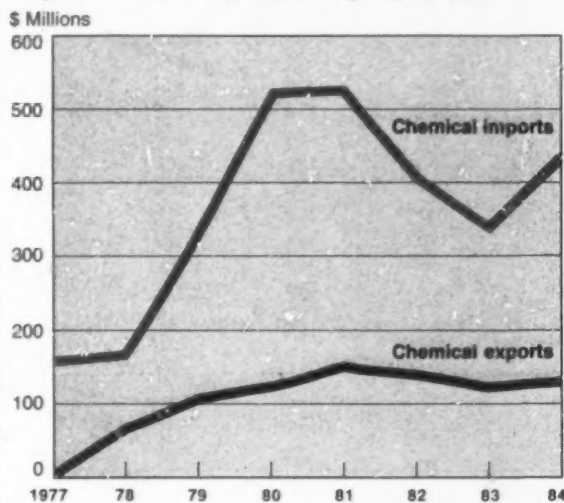
PRICES: Higher for most chemicals

Industry selling price indexes, 1971 = 100	Annual average			Change 1983-84
	1984	1983	1982	
All manufacturing	310.9	298.8	288.8	4%
Chemicals and chemical products	327.8	316.6	306.9	4
Industrial chemicals--inorganic	360.7	341.6	337.5	6
Ammonium nitrate ^a	218.5	208.9	221.5	5
Chlorine	381.7	360.2	315.5	6
Oxygen	257.3	237.7	224.0	8
Sodium hydroxide	461.1	467.1	450.1	-1
Industrial chemicals--organic	443.7	439.2	429.7	1
Plastics and synthetic resins	328.8	314.3	297.7	5
Alkyds	224.8	210.5	209.0	7
Phenol-formaldehyde	377.5	354.3	344.5	7
Polyethylene	323.5	309.9	290.2	4
Fertilizers, mixed	296.7	284.2	294.5	4
Pharmaceuticals and medicinals	250.3	233.6	211.9	7
Paint and varnish	302.6	304.3	300.0	-1
Pesticides	339.6	332.7	316.6	2
Synthetic fibers	250.3	242.6	254.9	3
Petroleum refineries	714.7	684.7	643.7	4
Benzene	423.1	446.3	427.4	-5
Toluene	622.9	606.0	620.4	3
Xylene	559.3	544.6	558.0	3

^a Fertilizer grade. Source: Statistics Canada

5 Foreign Chemical Industries—Mexico

Imports rebound, widening trade deficit



Note: Trade in primary petrochemicals only; does not include secondary chemicals.
Source: Petróleos Mexicanos

DOMESTIC SALES: Generally above 1983

Thousands of metric tons ^a	1984	1983	1982	1981	Change 1983-84
Acetaldehyde	212	200	156	124	6%
Acrylonitrile	84	86	71	74	-2
Ammonia, anhydrous	1667	1455	1338	1205	15%
Benzene	12	11	13	12	9
Butadiene	106	84	66	70	26
Cyclohexane	50	51	50	53	-3
Dodecylbenzene	101	107	111	92	-5
Ethylene oxide	112	105	78	78	6
Hexane	50	47	54	51	7
Isopropyl alcohol	58	54	47	32	8
Methanol	162	140	129	125	16
Polyethylene, high density	137	120	120	100	14
Polyethylene, low density	222	251	261	258	-11
Styrene	125	116	118	117	7
Sulfur	478	319	365	428	50
Toluene	85	81	86	88	5
Vinyl chloride	259	206	139	145	26
o-Xylene	32	33	27	27	-5
p-Xylene	263	131	187	187	101

^a Domestic sales by Petróleos Mexicanos (Pemex) of primary petrochemicals. Source: Pemex

CHEMICAL IMPORTS: Sharp rises for many

Thousands of metric tons ^a	1984	1983	1982	1981	Change 1983-84
Acetaldehyde	70	42	13	6	66%
Acrylonitrile	34	28	17	20	19
Benzene	0	0	12	21	—
Butadiene	67	45	50	55	49
Cyclohexane	26	3	13	8	872
Dichloroethane	57	25	0	2	130
Dodecylbenzene	49	55	47	33	-10
Ethylbenzene	16	6	16	11	174
Ethylene	0	0	31	15	—
Ethylene oxide	11	0	0	31	—
Isopropyl alcohol	44	25	31	15	75
Perchloroethylene	15	9	12	17	67
Polyethylene, high density	19	49	17	10	-62
Polyethylene, low density	63	88	106	126	-29
Propylene	26	17	22	24	54
Propylene tetramer	12	6	15	23	110
Styrene	93	66	61	89	42
Toluene	37	0	12	23	—
Vinyl chloride	109	75	71	84	46
o-Xylene	0	7	10	12	—
p-Xylene	119	25	131	148	383

^a Imports by Petróleos Mexicanos (Pemex) of primary petrochemicals. Source: Pemex

PRODUCTION: Lower for most chemicals

Thousands of metric tons ^a	1984	1983	1982	1981	Change 1983-84
Acetaldehyde	147	153	149	122	-4%
Acrylonitrile	49	55	53	54	-11
Ammonia, anhydrous	2156	2355	2469	2183	-8
Benzene	156	139	96	77	13
Butadiene	20	18	15	12	9
Cyclohexane	30	49	35	44	-38
Cumene	33	37	20	2	-10
Dichloroethane	220	265	201	117	-17
Dodecylbenzene	51	57	62	60	-10
Ethane	1574	1638	1550	1337	-4
Ethylbenzene	31	24	23	29	28
Ethylene	643	645	396	378	0
Ethylene oxide	97	112	79	48	-13
Hexane	95	64	76	66	47
Hydrochloric acid	77	79	47	33	-2
Isopropyl alcohol	14	12	11	16	19
Methanol	197	206	191	180	-4
Nitrogen	47	45	39	30	5
Oxygen	200	214	208	159	-6
Polyethylene, high density	76	82	78	78	-7
Polyethylene, low density	134	88	93	91	51
Propylene	208	191	158	156	9
Propylene tetramer	35	30	38	35	19
Styrene	30	24	29	33	26
Sulfur, recovered	461	377	425	426	22
Toluene	216	223	138	132	-3
Vinyl chloride	132	134	79	57	-2
m- and p-Xylene	225	197	99	87	14
o-Xylene	43	39	16	17	11

^a Production of Petróleos Mexicanos (Pemex) of primary petrochemicals. Source: Pemex

In 1984, East Europe and the Soviet Union continued the moderate upturn in economic growth that began in 1983, following several years of decelerating growth. Overall, industrial output for the region rose 4.4%, surpassing the goal of 4.0%. Only Bulgaria fell short of its plan.

The chemical industry continued to rebound in 1984, as well, led by East Germany's 9.4% production increase. Soviet production of plastics was up 9%, and output of mineral fertilizers, pesticides, and sodium hydroxide rose 3%. For many major chemical products the Soviet Union accounts for as much output or more than all the other East European nations combined.

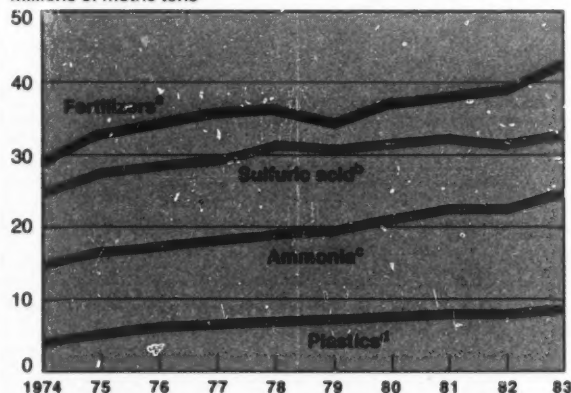
MAN-MADE FIBERS: Growth is moderate for noncellulosics, but cellulosics stagnate

Production, thousands of metric tons	1983	1982	1981	1980	Change 1982-83
NONCELLULOSIC FIBERS^a					
Bulgaria	60	52	56	54	15%
Czechoslovakia	105	102	90	76	3
East Germany	144	134	134	139	8
Hungary	21	20	21	20	2
Poland	148	128	119	163	15
Romania	156	151	154	136	3
U.S.S.R.	622	594	573	550	5
TOTAL	1256	1182	1148	1139	6%
CELLULOSIC FIBERS^a					
Bulgaria	39	38	39	36	3%
Czechoslovakia	58	55	54	55	5
East Germany	165	162	169	168	2
Hungary	6	8	8	9	-16
Poland	69	64	64	86	8
Romania	60	58	65	64	2
U.S.S.R.	645	635	646	650	2
TOTAL	1042	1020	1044	1068	2%

^a Excluding olefins and textile glass. Source: Textile Economics Bureau

Output is rising for several major chemical products

Millions of metric tons



^a As N, P₂O₅, and K₂O. ^b 100% H₂SO₄. ^c Nitrogen content. ^d Including resins for man-made fibers in U.S.S.R. Note: Data for U.S.S.R., Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania.

Sources: Central Intelligence Agency, Department of Agriculture, C&EN estimates

PRODUCTION GROWTH: Generally higher

% annual change in gross output	1984	1983	1982	1981	1980
U.S.S.R. and East Europe					
All industry	4.4%	4.3%	2.4%	2.2%	3.4%
Bulgaria					
All industry	4.5	3.9	4.6	4.9	4.2
Chemicals and rubber	6.0	5.9	6.4	4.3	11.1
Czechoslovakia					
All industry	3.9	2.8	1.1	2.1	3.5
Chemicals and rubber	na	3.5	1.1	1.7	4.8
East Germany					
All industry ^a	4.2	4.1	3.1	4.7	4.7
Chemicals and rubber	9.4	3.0	5.6	2.5	3.3
Hungary					
All industry	3.0	1.4	2.5	2.4	-2.0
Chemicals and rubber ^b	na	1.4	1.9	3.1	-2.1
Poland					
All industry	5.3	6.4	-2.1	-10.8	0.0
Chemicals and rubber	na	8.1	0.1	-11.4	0.4
Romania					
All industry	6.7	4.7	1.1	2.6	6.5
Chemicals and rubber	na	5.3	1.4	3.9	6.8
U.S.S.R.					
All industry ^c	4.2	4.2	2.9	3.4	3.6
Chemicals and rubber ^c	6.0	5.5	3.0	5.9	5.6
All industry ^d	na	3.5 ^e	2.3	2.4	2.9
Chemicals and rubber ^d	na	6.0 ^e	1.8	4.0	4.7

^a Industrial commodity production. ^b For state and cooperative industry only. ^c Figures based on official Soviet statistics. ^d Figures based on Central Intelligence Agency estimates, giving lower results because of postulated upward bias in official figures. ^e Preliminary figure. na = not available. Sources: United Nations Economic Commission for Europe and Foreign Broadcast Information Service, based on official national statistics; Central Intelligence Agency

AGRICULTURAL CHEMICALS: Fertilizer supplies were relatively unchanged last year

Thousands of metric tons	1984	1983	1982	1981	1980
Bulgaria					
Fertilizer supply ^a	1,015 ^b	1,009	1,038	1,044	830
Pesticide supply ^c	na	33.9	40.4	48.6	39.9
Czechoslovakia					
Fertilizer supply ^a	1,750	1,776	1,741	1,720	1,730
East Germany					
Fertilizer supply ^a	1,450 ^b	1,451	1,400	1,726	1,637
Pesticide supply ^c	na	26.0	26.7	27.0	27.0
Hungary					
Fertilizer supply ^a	1,510	1,586	1,528	1,485	1,399
Poland					
Fertilizer supply ^a	3,424	3,182	3,346	3,116	3,635
Pesticide supply ^c	11.1	14.7	16.3	12.4	9.3
Romania					
Fertilizer supply ^a	1,289	1,157 ^b	1,409	1,618	1,185
U.S.S.R.					
Fertilizer supply ^a	23,100	22,977	20,152	19,176	18,763
Nitrogen ^a	10,385 ^b	10,302	9,038	8,383	8,262
Phosphate ^{a,*}	6,465 ^b	6,465	6,117	5,879	5,590
Potassium ^a	6,240 ^b	6,201	4,991	4,905	4,904
Pesticide supply ^d	576	557	533	504	474

^a Nutrient content basis, as N, P₂O₅, or K₂O. ^b Estimated. ^c On basis of active substance. ^d On conventional weight basis. ^e Includes ground phosphate rock. na = not available. Sources: Department of Agriculture and Foreign Broadcast Information Service, based on official national statistics

5 Foreign Chemical Industries—Eastern Europe

PRODUCTION: Growth was slight last year for several important chemical products

Thousands of metric tons, unless otherwise noted

	1984 ^a	1983	1982	1981	1980
U.S.S.R.					
Sulfuric acid, 100 %	25,300	24,714	23,801	24,095	23,033
Mineral fertilizers ^b	30,300	29,727	26,738	25,999	24,767
Nitrogen ^b	13,225	13,007	11,593	10,705	10,241
Phosphate ^{b,c}	7,500	7,417	7,057	6,836	6,455
Potassium ^b	10,065	9,294	8,079	8,449	8,064
Synthetic ammonia ^d	na	16,770	14,605	14,718	13,762
Plastics ^e	4,800	4,419	4,058	4,089	3,637
Sodium hydroxide, 100 %	2,970	2,853	2,763	2,757	2,755
Synthetic rubber ^f	na	1,810	1,795	1,860	1,880
Pesticides ^g	576	557	533	504	474
Rubber tires ^h (thousands of units)	63,700	62,000	61,700	60,500	60,100

BULGARIA

	1984 ^a	1983	1982	1981	1980
Sulfuric acid, 100 %	908	861	916	920	852
Mineral fertilizers ^b	695	687	698	710	653
Nitrogen ^b	486	483	459	453	436
Phosphate ^b	209	204	239	258	217
Synthetic ammonia ^d	na	1,124	1,033	1,023	1,009
Plastics	na	398	337	290	255
Sodium hydroxide, 100 %	163	147	155	151	162
Synthetic rubber	na	25	25	30	30
Pesticides ⁱ	na	21	20	20	19

CZECHOSLOVAKIA

	1984 ^a	1983	1982	1981	1980
Sulfuric acid, 100 %	1,246	1,244	1,252	1,315	1,284
Mineral fertilizers ^b	1,191	1,175	1,166	1,139	1,233
Nitrogen ^b	576	591	568	539	618
Phosphate ^{b,c}	398	378	387	394	412
Potassium ^{b,d}	217	206	211	206	203
Synthetic ammonia ^d	na	809	728	711	841
Plastics	1,039	1,006	956	913	894
Sodium hydroxide, 100 %	na	330	324	330	324
Synthetic rubber	na	67	66	63	60
Pesticides ⁱ	na	16	16	16	16

EAST GERMANY

	1984 ^a	1983	1982	1981	1980
Sulfuric acid, 100 %	na	926	920	948	958
Mineral fertilizers ^b	na	4,714	4,669	4,787	4,735
Nitrogen ^b	1,026	968	948	967	943
Phosphate ^{b,c}	na	315	286	360	370
Potassium ^b	3,465	3,421	3,434	3,460	3,422

Thousands of metric tons, unless otherwise noted

	1984 ^a	1983	1982	1981	1980
Synthetic ammonia^d	na	1,210	1,167	1,203	1,181
Plastics	na	1,030	990	998	861
Sodium hydroxide, 100 %	na	687	695	631	626
Synthetic rubber	na	155	155	155	150
Pesticidesⁱ	na	54	53	53	51
Rubber tires^g (thousands of units)	na	7,420	7,056	7,026	7,067

HUNGARY

	1984 ^a	1983	1982	1981	1980
Sulfuric acid, 100 %	568	625	589	546	608
Mineral fertilizers ^b	1,109	1,110	1,071	1,112	1,045
Nitrogen ^b	678	684	660	684	649
Phosphate ^b	269	282	269	276	257
Potassium ^{b,j}	162	140	142	152	139
Synthetic ammonia ^d	na	812	792	819	795
Plastics	na	345	326	314	328
Sodium hydroxide, 100 % ^k	na	192	178	180	189
Pesticides ⁱ	36	36	26	29	28

POLAND

	1984 ^a	1983	1982	1981	1980
Sulfuric acid, 100 %	2,770	2,786	2,676	2,776	3,019
Mineral fertilizers ^b	2,356	2,323	2,284	2,241	2,238
Nitrogen ^b	1,369	1,341	1,298	1,274	1,290
Phosphate ^b	869	872	868	866	843
Potassium ^{b,j}	118	111	118	101	105
Synthetic ammonia ^d	na	1,430	1,384	1,465	1,483
Plastics	619	559	479	504	576
Sodium hydroxide, 100 %	379	392	363	401	416
Synthetic rubber	119	120	100	111	118
Pesticides ⁱ	na	9	9	8	10
Rubber tires ^h (thousands of units)	8,104	7,890	5,693	na	8,743

ROMANIA

	1984 ^a	1983	1982	1981	1980
Sulfuric acid, 100 %	na	na	1,600	1,814	1,756
Mineral fertilizers ^b	3,073	2,913	2,692	2,640	2,451
Nitrogen ^b	na	2,091	2,008	1,822	1,707
Synthetic ammonia ^d	na	2,723	2,583	2,383	2,247
Plastics	na	633	591	584	579
Sodium hydroxide, 100 %	na	745	760	767	723
Synthetic rubber	159	147	160	146	150
Pesticides ⁱ	na	48	45	43	40

a Approximate figures. b Nutrient content basis, as N, P₂O₅, or K₂O. c Including production of ground phosphate rock for direct applications and phosphate animal feeds. d Nitrogen content. e Including resins for man-made fibers. f Estimated. g On conventional weight basis. h For all motor vehicle tires, excluding aircraft and bicycle tires. i On basis of active substance. j Imported potash added to domestically produced nitrogen and phosphate to form multinutrient fertilizer. k Including regenerated NaOH. na = not available. Sources: Central Intelligence Agency, Department of Agriculture, Foreign Broadcast Information Service, and PlanEcon Inc., based on official national statistics

SOVIET FOREIGN TRADE: Little change last year in dollar value

\$ Millions	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Exports ^a	\$91,120	\$91,469	\$87,168	\$79,377	\$76,437	\$64,912	\$52,435	\$45,227	\$37,269	\$33,407	\$27,374
Imports ^a	80,026	80,285	77,847	73,158	68,473	57,958	50,798	40,926	38,212	37,070	24,861
Trade balance	11,094	11,184	9,321	6,219	7,964	6,954	1,637	4,301	-943	-3,663	2,513
Chemical exports ^a	na	2,300 ^b	2,309	2,380	2,139	1,606	1,284	1,063	939	1,027	887
Chemical imports ^a	na	2,800 ^b	3,886	4,031	3,732	2,803	2,186	1,850	1,668	1,747	1,448
Chemical trade balance	na	-500 ^b	-1,577	-1,651	-1,593	-1,197	-904	-787	-729	-720	-561

a Free on board. b Approximate values. na = not available. Sources: Central Intelligence Agency, PlanEcon Inc., based on official Soviet statistics and exchange rates

KOREA

INDUSTRY TRENDS: Sharp gains in 1984

Index, 1980 = 100	1984	1983	1982	1981	Change 1983-84
Chemicals, petroleum, coal, rubber, and plastic products					
Production	140.7	123.7	105.9	102.5	14%
Shipments	132.6	119.5	102.4	101.6	11
Inventories	125.2	119.5	115.4	115.0	5
Industrial chemicals					
Production	126.4	116.0	101.8	103.7	9
Shipments	134.4	124.5	108.2	105.4	8
Inventories	117.3	114.2	121.1	126.9	3
Other chemical products					
Production	160.8	141.7	122.5	106.1	13
Shipments	158.7	139.2	119.4	106.7	14
Inventories	159.3	141.6	118.5	94.7	12
Rubber products					
Production	158.4	120.3	99.2	99.4	32
Shipments	158.2	120.1	98.3	95.3	32
Inventories	138.2	99.8	87.2	109.8	38
Plastic products					
Production	145.3	124.2	92.9	91.6	17
Shipments	146.1	123.6	92.6	91.3	18
Inventories	139.9	132.0	121.9	96.5	6
All manufacturing					
Production	160.6	139.0	119.4	113.4	16
Shipments	153.6	135.8	116.2	111.3	13
Inventories	138.0	126.0	126.5	110.8	10

Source: Korean Bureau of Statistics

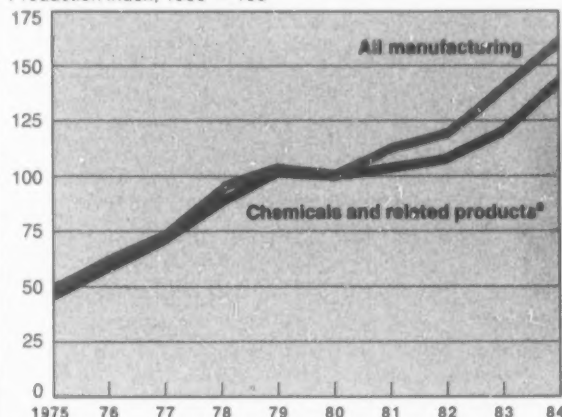
FOREIGN TRADE: Chemical deficit widens

\$ Millions	1984	1983	1982	1981
Exports ^a	\$29,245	\$24,445	\$21,853	\$21,254
Imports ^b	30,631	26,192	24,251	26,131
Trade balance	-1,386	-1,747	-2,398	-4,877
Chemical exports	918	747	740	682
Chemical imports	2,762	2,279	2,084	2,109
Chemical trade balance	1,844	1,532	-1,344	-1,427

a Free on board. b Includes cost, insurance, freight. Source: Korean Bureau of Statistics

Production of chemicals lags behind manufacturing output overall

Production index, 1980 = 100



a Includes petroleum, coal, rubber, and plastic products.
Source: Korean Bureau of Statistics

PRODUCTION: Last year was strong

Thousands of metric tons	1984	1983	1982	1981	Change 1983-84
Sulfuric acid	1975	1610	1596	1304	23%
Complex fertilizers	1861	1614	1667	1211	15
Ammonia	565	523	661	908	8
Urea fertilizers	858	737	788	1070	16
Ethylene	526	491	374	374	7
Polyethylene	317	279	218	200	14
Polyester fibers	265	217	189	193	22
Insecticides	110	87	58	54	27
Synthetic detergents	62	57	52	57	8

Sources: Korean Bureau of Statistics, Korean Economic Planning Board

AUSTRALIA

PRODUCTION: Plastics bounce back

Thousands of metric tons	1984 ^a	1983 ^a	1982 ^a	1981 ^a	Change 1983-84
Chemicals and acids					
Hydrochloric acid, 100%	57	60	55	59	-5%
Nitric acid, 100%	189	189	180	182	0
Sulfuric acid, 100%	1726	1782	2027	1963	-3
Ammonium sulfate	217	200	207	211	8
Superphosphate ^b	2663	2986	3568	3770	-11
Plastics and resins	820	720	801	789	14
Synthetic detergents	221	216	211	200	2
Unsupported plastics film, sheeting	122	114	119	125	7
Polyethylene ^c	90	81	82	84	11
Polyvinyl chloride ^d	14	17	18	18	-17

a Years ending June 30. b Includes double and triple superphosphates and ammonium phosphate expressed in terms of single phosphate (22% P₂O₅ equivalent). c Low and high density. d Including copolymers. Source: Australian Bureau of Statistics

FOREIGN TRADE: Chemical imports rise fast

\$ Millions	1984 ^a	1983 ^a	1982 ^a	1981 ^a
Exports ^{b,c}	\$22,488	\$20,812	\$20,939	\$22,314
Imports ^d	21,847	20,515	24,608	22,068
Trade balance	641	297	-3,669	246
Chemical exports ^{b,c}	455	431	430	487
Medicinal products	108	102	95	95
Chemical imports ^d	1,953	1,671	1,955	1,842
Organic chemicals	550	441	530	509
Resins, plastic materials	441	343	460	416
Medicinal products	201	182	166	164
Chemical trade balance	-1,498	-1,240	-1,525	-1,355

a Years ending June 30. b Free on board. c Includes re-exports. d Values for customs purposes, free-on-board basis. Source: Australian Bureau of Statistics

5 Foreign Chemical Industries—Western Pacific

CHINA

PRODUCTION: Fibers and fertilizers scored big gains last year

Thousands of metric tons, unless otherwise noted	1984	1983	1982	1981	Change 1983-84
Fertilizer^a	14,820	13,789	12,781	12,390	8%
Nitrogen (N)	12,280	11,094	10,218	9,857	10
Phosphate (P ₂ O ₅) ^b	2,520	2,665	2,537	2,508	-5
Potash (K ₂ O)	40	29	25	26	38
Sulfuric acid, 100%	8,130	8,695	8,174	7,807	-6
Sodium hydroxide	2,220	2,123	2,073	1,923	5
Sodium carbonate	1,880	1,793	1,735	1,652	5
Calcium carbide	na	1,807	1,674	1,513	na

Thousands of metric tons, unless otherwise noted	1984	1983	1982	1981	Change 1983-84
Plastics	1,160	1,121	1,003	916	3%
Man-made fibers	730	544	517	527	34
Synthetic detergents	810	680	569	478	19
Ethylene	648	654	565	505	-1
Pesticides	310	332	457	484	-7
Pharmaceuticals	52	48	42	37	9
Synthetic rubber	na	169	136	125	na
Rubber tires^c	15,345	12,710	8630	7290	21

^a Nutrient content. ^b Including production of ground phosphate rock for direct application and phosphate animal feeds. ^c Not including wheelbarrow and bicycle tires. na = not available. Sources: State Statistical Bureau of the People's Republic of China, Chinese Ministry of Chemical Industry

CHEMICAL IMPORTS: Plastics, fertilizers dip

\$ Millions ^a	1983	1982	1981	Change 1982-83
Fertilizers^b	\$ 574	\$ 622	\$ 766	-8%
Nitrogenous fertilizer	199	351	455	-43
Chemical elements and compounds	572	521	475	10
Organic chemicals	416	415	381	0
Plastic materials, resins	570	634	482	-10
Dyeing, tanning, and coloring materials	116	141	116	-18
Medicinal products	43	34	30	26
Essential oils, perfume, and cleansing materials	39	22	16	77
Other chemicals^c	318	196	160	62
TOTAL	\$2233	\$2170	\$2046	3%

^a Free on board. ^b Manufactured. ^c Includes explosives and pyrotechnic products; mineral tar and crude chemicals from coal, oil, and natural gas; and chemical materials and products not elsewhere specified. Source: Central Intelligence Agency, estimated from data reported by China's trade partners

CHEMICAL EXPORTS: Little change overall

\$ Millions ^a	1983	1982	1981	Change 1982-83
Chemical elements and compounds	\$ 541	\$ 581	\$ 583	-7%
Organic chemicals	304	308	326	-1
Medicinal products	237	223	215	6
Explosives and pyrotechnic products	113	110	96	3
Essential oils, perfume, and cleansing materials	110	98	97	12
Dyeing, tanning, and coloring materials	82	71	67	15
Plastic materials, resins	54	43	67	24
Mineral tar and crude chemicals^b	16	31	23	-48
Fertilizers^c	3	3	1	7
Other chemical products	135	137	188	-1
TOTAL	\$1290	\$1297	\$1335	-1%

^a Free on board. ^b From coal, oil, and natural gas. ^c Manufactured. Source: Central Intelligence Agency, estimated from data reported by China's trade partners

TAIWAN

INDUSTRY TRENDS: Fertilizers are only laggard

Industrial production indexes, 1981 = 100	1984	1983	1982	1981	Change 1983-84
All manufacturing	132.2	117.0	101.3	100.0	13%
Chemical materials	139.6	115.4	99.6	100.0	21
Basic chemicals	118.6	107.1	99.7	100.0	11
Petrochemicals	144.8	114.3	95.3	100.0	27
Fertilizers	75.2	74.0	72.9	100.0	2
Synthetic fibers	136.6	117.8	104.1	100.0	16
Plastics and resins	153.1	123.8	105.0	100.0	24
Chemical products	141.8	125.2	116.4	100.0	13

Source: Taiwan Ministry of Economic Affairs

FOREIGN TRADE: Wider gap for chemicals

\$ Millions	1984	1983	1982	1981
Exports^a	\$30,456	\$25,123	\$22,204	\$22,611
Imports^b	21,959	20,287	18,888	21,200
Trade balance	8,497	4,836	3,316	1,411
Chemical exports^{a,c}	1,244	1,041	1,012	973
Chemical imports^{b,c}	3,203	2,814	2,312	2,705
Chemical trade balance	-1,959	-1,773	-1,299	-1,731

^a Free on board. ^b Includes cost, insurance, and freight. ^c For chemicals and chemical products. Sources: Taiwan Council for Economic Planning & Development, C&EN estimates

PRODUCTION: Olefins, aromatics up strongly

Thousands of metric tons, unless otherwise noted	1984	1983	1982	1981	Change 1983-84
Man-made fibers	970	840	730	687	16%
Sulfuric acid	762	678	685	819	12
Polyvinyl chloride	634	522	459	456	21
Ethylene	660	499	452	443	32
Vinyl chloride	492	458	434	411	7
Ammonium sulfate	434	381	373	504	14
Ammonia, anhydrous	327	378	386	494	-14
Sodium hydroxide	351	295	359	373	19
Xylene^a	334	275	230	277	21
Compound fertilizer	301	275	247	330	9
Propylene	341	250	225	204	37
Hydrochloric acid	241	212	191	184	13
Benzene^a	281	182	130	137	54
Urea	179	171	175	285	5
Calcium superphosphate	177	159	160	226	11
Ethylene glycol	189	151	120	156	25
Oxygen^b	198	125	164	174	58
Toluene^a	195	115	113	172	70
Paints	123	108	97	84	15

^a Millions of liters. ^b Millions of cubic meters. Source: Taiwan Ministry of Economic Affairs

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JUNE 17, 1985

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Fighting cancer with biological
response modification
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wins 1986
Priestley Medal**
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Priestley Medal

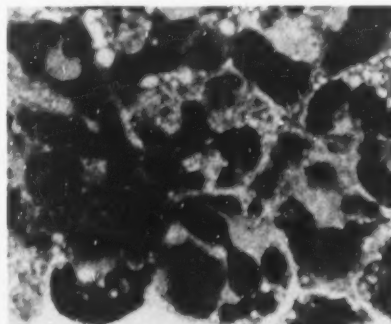
Karl Folkers, director of Institute for Biomedical Research at the University of Texas, wins 1986 ACS Priestley Medal. Page 36

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News Focus

Natural substances, such as interferons, that stimulate the body's immune system show promise for treating certain types of cancer. Page 10

SCIENTIFIC MANPOWER:

Volume compiles data, maps trends

Chemists can expect a steady, if modest, growth in job openings in the next few years, with the balance between the supply of chemists available and the demand for their services staying about even, thus keeping unemployment low. That's the essence of one of the 50 or so statistical reports dealing with the supply and demand for scientists and engineers that have been distilled into the Scientific Manpower Commission's latest examination of scientific employment: "The Technological Marketplace."

Although all of the data have been published previously elsewhere, including some of it in C&EN, the report pulls together in one place most of the statistically based information on trends in technological employment over the past decade along with projections for what is expected in the next decade and a half. The report's data come from the National Science Foundation, other federal agencies, universities, professional societies, and private organizations concerned with the supply of and demand for scientists and engineers. The data are analyzed and trends are pointed out for fields such as chemistry and chemical engineering, and for science and engineering as a whole.

Two significant changes occurred in the 1970s in the supply of new

graduates in science and engineering, says the report's author, Betty M. Vetter: Science and engineering degrees became a substantially smaller fraction of all degrees awarded, and the proportion of science and engineering degrees awarded to women rose steadily. The overall drop comes mostly at the doctoral level where the fraction of all degrees represented by science and engineering fell from 62% in 1960 to 50% in 1979. From 1973 to 1983 the actual number of science and engineering doctoral degrees fell 1%; at the same time, the number of these degrees awarded to women rose 98% as the number awarded to men fell 15%.

At the bachelor's level, a "remarkably consistent" 29 to 32% have majored in science or engineering over the past two decades, the report finds. From 1972 to 1982, the absolute number rose 6.1% (reflecting higher overall college enrollments during that period). The number of those degrees awarded to women rose 44%; the number awarded to men dropped 8.2%. By 1982, women accounted for 37% of the bachelor's degrees earned in science and engineering. As the future college age population decreases, the number of bachelor's degrees awarded in these fields is expected to drop steadily through 1998.

Similar trends may be seen in chemistry degrees over the period. Bachelor's degrees reached their peak levels in 1969 when 11,807 were awarded, 18% of which went to women. The number of graduates declined through 1973, to a minimum of 10,222, rose through 1979, and have been declining since then. In 1982, bachelor's degrees were earned by 11,062 students, 31% of whom were women. Doctoral degrees in chemistry peaked in 1970 at 2208 and have been rising since 1977 to reach 1722 in 1982. The proportion of women earning those degrees has risen steadily over the past 25 years, however, from 5% of the total in 1960 to 15% in 1980 and 1982.

Fortunately for chemistry graduates and other chemical professionals, current demand for chemists seems to be pretty much in balance with their supply, so that chemists experience a only a 1.7% imbalance between supply and demand, a condition that is expected to continue, at least for the next several years. Surveys of firms hiring chemists and chemical engineers find fewer than 5% report shortages in the availability of people in either of these fields. Where shortages exist, they are for experienced chemists and chemical engineers, not for recent graduates. Salary offers for recent graduates in both chemistry and chemical engineering remain high, however, suggesting that, although there are not serious shortages of these graduates, there are not surpluses either.

Copies of the report, "The Technological Marketplace: Supply and Demand for Scientists and Engineers," are available for \$25 from the Scientific Manpower Commission, 1776 Massachusetts Ave., N.W., Washington, D.C. 20036. □

Chemists can expect slow, steady growth in jobs, continuing low unemployment rates

Thousands	1981			1987			% annual change
	Total supply	Demand	% surplus	Total supply	Demand	% surplus	
All scientists	586.2	523.0	7.7%	639.9	584.7	8.6%	4.1%
Chemists	95.5	93.8	1.7	104.6	102.8	1.7	2.5
All engineers	1217.2	1207.6	0.8	1437.3	1423.1	1.0	4.5
Chemical engineers	58.0	55.4	4.5	64.2	60.9	5.1	2.7

Source: National Science Foundation

U.S. Chemical Producers Weigh Antiapartheid Tack in South Africa

Companies believe they can do more good for blacks by continuing their operations there, but pressure to disinvest is increasing sharply

David Webber, C&EN New York

On the uneasy ground where concerns of profitability and moral responsibility meet, U.S. chemical companies with operations in South Africa are pondering their role in the fight to end apartheid.

Up to now, most of the 28 or so U.S. chemical and diversified chemical-oriented firms doing business there have approached the bitter issue under the philosophy that good jobs and nonworkplace philanthropy will improve conditions for nonwhites and contribute to a gradual end to the government's segregation policies. But this ameliorative approach—along which companies have generally found it possible to carry on business and simultaneously discharge what they consider their social responsibility—is now coming under increasingly strident attack from impatient antiapartheid groups, which want U.S. companies to withdraw from South Africa entirely.

Dozens of bills before Congress, state legislatures, and municipal bodies in the U.S. currently seek a variety of antiapartheid measures ranging from economic sanctions against South Africa to bans on further investment there to the divestiture by government pension funds of stocks of companies doing business there. In addition, highly publicized student protests—such as those at Columbia University and the University of California, Berke-

ley, this spring—have both increased the pressure on educational institutions to sell off their investments in companies operating in South Africa and heightened public awareness of the apartheid issue.

These tactics threaten companies, including chemical producers, operating in South Africa in several ways. A bill passed by the House this month [H.R. 1460, primary sponsor William H. Gray III (D.-Pa.)], would ban new investment, new bank loans, and computer exports to South Africa as well as bar the importation of South African gold coins. Most critical for U.S. businesses would be the ban on investment; companies would be unable to expand or modernize their facilities there. A narrower Senate bill, S. 995, authored by Foreign Relations Committee chairman Richard

G. Lugar (R.-Ind.), has been approved by the Foreign Relations Committee.

The stock divestiture movement menaces chemical and other companies in a different way. Meant as a stick with which to drive U.S. companies into quitting South Africa, stock divestiture could mean, in its strongest possible form, the dumping of large blocks of a company's stock on the market. If executed over a brief period of time, such a maneuver undoubtedly would knock a stock's price down considerably. And for the chemical industry, the public image of which still bears the unattractive marks of Bhopal, agent orange, and Times Beach, further linking of the names of some of its members to a repugnant issue—whatever the qualifications—is undesirable.

The Sullivan principles: a code of conduct

Almost all U.S. chemical companies with operations in South Africa are signatories to the Sullivan principles, a code of conduct developed in 1977 by the Rev. Leon H. Sullivan, a Baptist minister in Philadelphia and a member of General Motors' board of directors. The code's intent is threefold: to promote racial equality in employment practices for U.S. firms operating in South Africa, to promote programs that can have a significant impact on improving the living conditions and quality of life for the nonwhite population, and to be a major contributing factor in the end of apartheid. Starting with 12 original signatories, the list of firms that have signed the principles has grown to include now about half of the more than 300 U.S. firms with operations in South Africa. Adherence to the Sullivan principles requires:

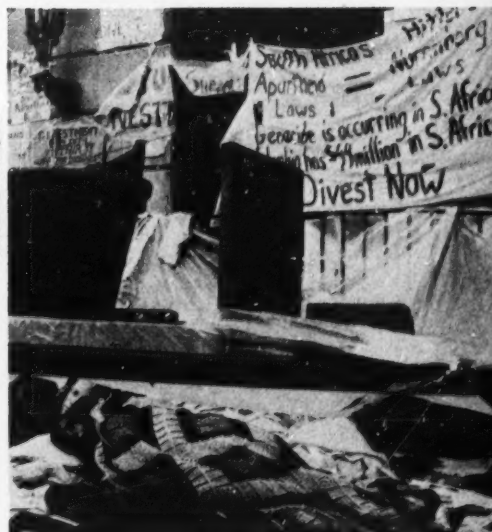
- Nonsegregation of the races in all eating, comfort, and work facilities.
- Equal and fair employment practices for all employees.
- Equal pay for all employees doing equal or comparable work for the same period of time.
- Initiation and development of training programs that will prepare blacks, coloreds, and Asians—the three categories the South African government uses for nonwhites—in substantial numbers for supervisory, administrative, clerical, and technical jobs.
- Increasing the number of blacks, coloreds, and Asians in management and supervisory positions.
- Improving the quality of employees' lives outside the work environment in such areas as housing, transportation, schooling, recreation, and health facilities.

For the most part, chemical companies do not seem to have a tremendous amount to lose in South Africa if forced to disinvest, at least in relative terms. Assets held in that country tend to be relatively small. Nor are sales typically significant on the scale of total corporate revenues. Most U.S. chemical producers derive far less than 1% of global sales from their South African operations.

Companies say that they are not considering disinvestment. The explanation given by them for remaining in South Africa is nearly uniform and essentially twofold: They are in the business of making money for their shareholders and therefore continue to operate profitable concerns; and they believe their largely U.S.-standard jobs and financial assistance in the community offer nonwhites concrete help, whereas disinvestment, they say, would have no more than a symbolic impact on apartheid while penalizing those very blacks and other nonwhites whose lives have been improved through employment with the U.S. companies.

Both proponents and critics of the corporate rationale offer statistics in support of their views. Those calling for disinvestment point out that however good the U.S. firms' jobs are, they account for only a few per cent of South African employment. As a result, these critics say, only a proportionately small number of nonwhites are helped, but the economic activity brought to the nation strengthens the apartheid regime. For the good of the great bulk of the country's nonwhites, U.S. investment there should be dismantled, holds this point of view.

U.S. companies operating in South Africa, on the other hand, contend that the very fact that their activities account for such a small share of the South African economy—some \$2.5 billion out of a gross national product of \$90 billion—means their withdrawal would do little to loosen apartheid's grip on the country. If they were to cease business in protest of apartheid, they say, their operations probably would be either nationalized or bought by European or Japanese companies—none of which would be expected



Student protesters at Columbia call for divestiture of stock of U.S. companies operating in South Africa

to maintain an equivalent level of social responsibility.

And, even though the U.S. is South Africa's largest single trading partner, companies like to point out that the apartheid government is not without resources in the event of economic sanctions. In the early 1960s, for example, the United Nations imposed a boycott of arms sales to South Africa. The nation responded by building its own arms industry, and it is now a net exporter of weapons. Furthermore, the antidisinvestment party warns, South Africa is, except for the Soviet Union, the sole source of several militarily and industrially critical minerals. South Africa, antiapartheid hardliners are reminded, is potentially capable of implementing some painful boycotts of its own.

Companies concede that, at least as far as they are concerned, stock divestiture, if carried out on a broad scale, could have a deeper impact. How much, however, is hard to quantify at this point. There have been substantial divestitures involving chemical company stock, among others, in the past. Over the course of 1982, for example, the state of Massachusetts sold about \$130 million worth of investments held by its public employee pension funds, including \$3.4 million of Dow Chemical stock, \$14.1 million of Du Pont stock, \$1.1 million of Pfizer stock, and \$2.5 million of Union Carbide stock. Since 1982, Connecticut has been selling stock of some companies.

Most firms say they have not been noticeably hurt by divestiture so far. At the most, some analysts say, even divestiture by major institutions could have an impact lasting no more than six to nine months. "The stock would be absorbed by other investors," comments Jack Henry, chemicals analyst at E. F. Hutton. "Long term, there would be no effect on stock prices and no effect on the operations of these companies." Remarks another observer: "It would be nothing more than the sale of stock by the conscience-stricken to the indifferent."

Still, antiapartheid sentiment in the U.S. seems to have reached a new high-water mark. Attempting to gauge the national mood, a recent *New York Times* editorial asserts that "the urge to punish South Africa for apartheid is now palpable throughout the U.S." For U.S. chemical companies, a number of which have had shareholder proposals calling for disinvestment included in recent annual meetings, reconsideration of the current approach may be inevitable.

Up to now, the majority of U.S. chemical companies operating in South Africa have dealt with the apartheid issue chiefly by following the Sullivan principles, a voluntary code of conduct drafted in 1977 by the Rev. Leon H. Sullivan, a Baptist minister in Philadelphia and a General Motors board member.

Chemical companies generally have rated in the fair to good categories in their adherence to the prin-

Most U.S. chemical firms get good rating on social responsibility in South Africa

Parent company	Types of operations	% 1984 sales from South Africa	Employment ^a			Signed Sullivan principles	Sullivan principles rating ^b
			Total	White	Nonwhite		
American Cyanamid	Mfg	1%	671	269	402	Yes	1,4
Dow Chemical	Sales, mfg	<1%	202	137	65	Yes	2,4
Du Pont	Sales	<1%	30	25	5	Yes	1
W. R. Grace	Sales, mfg	<1%	134	na	na	Yes	2
International Minerals	Mining	<1%	239	22	217	Yes	2,4
Monsanto	Sales	<1%	34	25	9	Yes	2
Nalco Chemical	Mfg	na	200	na	na	Yes	3
Olin	Sales, mfg	<1%	273	122	151	Yes	1,2,3
Rohm & Haas	Mfg	na	102	36	66	Yes	2,4
Union Carbide	Sales, mfg	<1%	1800	500	1300	Yes	1,2,4

^a Figures are approximate. "Nonwhite" includes "blacks, coloreds, and Asians," the government categories for the nonwhite population. b 1) Making good progress; 2) Making progress; 3) Needs to become more active; 4) Companies with no more than 25 employees in South Africa or owning less than 50% of South African subsidiary. Multiple ratings reflect multiple subsidiaries. na = not available. Source: International Council for Equality of Opportunity Principles: "Eighth Report on the Signatory Companies to the Sullivan Principles (Oct. 1984)," communication with industry

ciples, according to annual audits of signatory companies by Arthur D. Little, Cambridge, Mass. In the October 1984 audit, for example, eight operations were ranked in category I (making good progress), 10 fell into category II (making progress), and three were placed in category III (needs to become more active). Other operations were mostly too small or were less than half-owned by the U.S. parents; as a result, they were not included in the three major categories.

The cost of a poor ranking, at least in terms of image, can be immediate. Last year, for instance, Nalco Chemical, which owns 50% of Anikem, a producer of water-treatment and other chemicals, was ranked in category III in the Sullivan principles audit for the fifth consecutive year. In response, the Iowa Episcopal Church, which held 400 shares of Nalco stock at the end of 1984, introduced a shareholder proposal at this March's annual shareholder meeting that the company either take whatever steps were necessary to achieve a higher rating in the October 1985 report or dispose of its South African operations as quickly as possible.

Nalco management responded that Anikem has made "considerable progress toward meeting the goals of those principles" and noted that, as a nonmajority stockholder, Nalco cannot dictate to Anikem and that divestment would deprive shareholders of their investment and

Anikem of the example of "Nalco's leadership in fair employment practices."

Nalco's management also termed the Arthur D. Little classifications "subjective," reflecting widespread industry discomfort with the rating system, which ranks firms in comparison to each other rather than on an absolute scale. Nalco declares that its low rating does not mean that Anikem was not active in supporting the Sullivan principles, but that it was not so active as some other companies. The proposal was defeated.

Even the most active supporters of the Sullivan principles, however, cannot satisfy the intent of Sullivan's initiative by mere maintenance of previous achievements. That code is frequently revised. The "Fourth Amplification," drafted last November, requires the companies to support actively the freedom of blacks to work or live where they choose—freedoms currently curtailed by South African laws—and to support the ending of all apartheid laws.

Although chemical company signatories say they intend to support the new aspects of the principles, this increased focus on bringing about change outside the workplace makes their position more delicate. As companies operating in South Africa, they point out, they cannot break laws. Nor, they say, can they afford to be overtly abrasive toward the Pretoria government if they expect to continue to do business there and effect gradual gains.

"We don't adopt a confrontational kind of attitude," says Ned Brandt of Dow. "We don't make speeches about how terrible they are. We talk to them privately. That is much more effective, particularly respecting the Afrikaner mentality."

In addition, most U.S. companies in South Africa participate in the American Chamber of Commerce in South Africa, which, as an umbrella organization, has been urging the Pretoria government to eliminate a number of the strictures of apartheid. In March, for instance, the group submitted a set of proposals to a special cabinet committee under the chairmanship of the Minister of Constitutional Development & Planning. The proposals included the phasing out of geographical restrictions on blacks, the granting of freehold rights for urban blacks, the end of population removals, the end of the current migratory labor system (which bars blacks from bringing their families with them), the opening of central business districts to all races, and an end to the transfer of black citizenship from South Africa to homelands.

Nonetheless, the idea of discourse and gradual improvement as an answer to the apartheid issue is now losing currency among some of its strongest supporters in the U.S. Bills now under consideration in Congress reflect a belief among Representatives and Senators that the Administration's policy of "constructive engagement" with South Africa has failed. Even Sullivan now says that he thinks the Sullivan principles, along with other forces, should have two more years in which to try to end apartheid. If unsuccessful during that period, he says, the U.S. should impose a total economic embargo against South Africa and all U.S. firms there should withdraw.

At present, U.S. chemical companies in South Africa continue to operate as usual. Citing business reasons, they say for the most part that no new investment is planned in their operations there. They cannot be sure what to expect from Congress or Pretoria. What they can expect, it seems safe to say, is an increasingly emotional environment in which to press their arguments of gradual change. □

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technology show grows bigger
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LETTERS

CHEMICAL SAFETY

Perchlorates in doping polymers can pose hazards

The use of perchlorates in doping polymers is an example of the use of a hazardous material in an unusual manner. In a letter dated March 29, 1985, to the editor of C&EN, R. L. Elsenbaumer and G. G. Miller, Allied Corp., describe an incident which may serve to warn others who are using this type of procedure.

SIR: Recently a piece of perchlorate-doped polyacetylene film spontaneously detonated inside of an argon-filled dry box. Fortunately there were no injuries to personnel or loss of equipment. Since highly conductive perchlorate-doped polyacetylene is studied by a substantial number of people around the world, we wish to emphasize the potential hazards of handling this material. The details of the incident follow:

Perchlorate-doped polyacetylene was prepared by a slight modification of the method of Reynolds et al. [*J. Chem. Soc. Chem. Commun.*, 1358, 1982]. A piece of polyacetylene film was placed in contact with a solution of ferric perchlorate in toluene/nitromethane for 72 hours at room temperature. After washing and drying under high vacuum, the film was taken into an argon-filled dry box. A piece was cut from the sample and the remainder was stored under argon in a sealed vessel. Two weeks later, additional samples were needed, so the vessel was re-evacuated and taken back into the dry box. The vessel was refilled with argon and, as the top was being removed, the contents detonated.

We know of no reported incidents with this material, except Yang and Chien [*J. Polymer Sci., Poly. Chem. Ed.*, 23, 859 (1985)], in which they describe the thermal instability of perchlorate-doped polyacetylene. In TGA runs under nitrogen, samples of HClO_4 , $\text{Fe}(\text{ClO}_4)_3$ and electrochemically LiClO_4 doped polyacetylenes exploded at 130, 160, and 180 °C, respectively.

Before working with it in our laboratory, we prepared small quantities to determine the propensity to detonate. Hitting samples with a hammer, bending, cutting, tearing, or even putting them directly into an open flame did not provide any indication of instability. But, as is the case with anything containing the perchlorate anion, there is always the danger of a spontaneous detonation. Unless appropriate safety precautions can be taken, we strongly urge that the perchlorate ion be avoided as a dopant for conducting polymers.

The possible influence which the nitromethane may have on the stability of the perchlorate-doped material is not known, but no incidents have been reported in which this solvent has been a negative factor in the safe handling of this or any other doped polymer.

Ronald L. Elsenbaumer
Granville G. Miller
Allied Corp.
Morristown, N.J.

Bredig's earlier observation

SIR: C&EN reports (May 27, page 54) that the first oscillating catalysis observed was iodate-iodine decomposition of hydrogen peroxide (Bray, 1921). A clearly earlier observation was the pulsing decomposition of H_2O_2 on metallic mercury, reported by Bredig in *Z. physik. Chem.*, 42, 601 (1903). Iron and copper also have been reported to produce this effect with H_2O_2 , but the cyclic reaction on mercury is easily demonstrated (keep pH above 8 in modest H_2O_2 concentrations).

Ralph L. Wentworth, Cambridge, Mass.

Shared research credit

SIR: I would like to correct an error and omission in the article concerning solid ionic conductors by Shriver and Farrington that appeared in the May 20 issue of C&EN, page 42.

The early work at Ford Motor Co. on β -alumina included not only myself and Joseph T. Kummer (not James T. Kummer as given in the article), but also Neill Weber now at Ceramtec Inc., Salt Lake City. The research effort at Ford

on the sodium/sulfur battery was based on the elegant work of Weber, which lead to, among other things, the discovery of Li and MgO stabilized β -alumina. For example, see the paper on the Na/S battery (670179) presented by Weber at the Society for Automotive Engineers, January 1967.

Yung-Fang Yu Yao, Dearborn, Mich.

Corrections

• May 27, page 56: Silicon nitride ceramic materials are conventionally made by processes that do not involve either liquid intermediates or melttable or organic-soluble solids. In the process developed by chemists at MIT, hydrogen gas eliminated during the polymerization process arises from the release of hydrogen atoms located on adjacent silicon and nitrogen atoms, not silicon and carbon atoms.

• June 10, page 44: The financial data reported for Lubrizol Corp. have been transposed with those for Loctite Corp.

Mineral-Based Inorganics Face Slower Production Growth

Stagnating demand for lime, sulfur, potash, and phosphorus will hold output below highs set in late 1970s and early 1980s for years to come

Bruce F. Greek, C&EN Houston

Demand this year for the large-volume, mineral-based inorganics isn't expected to change much from last year. Growth has declined to minimal levels for three of these chemicals—lime, sulfur, and phosphorus. And the fourth—potash—will coast or possibly decelerate slightly. As demand levels off, a number of situations likely will result, including little growth in production, plant capacity, and capacity use, and pressure on selling prices.

Production of these mineral-based inorganics remains well below recent historical highs set either in the late 1970s or early 1980s. With little growth expected in demand

this year, and possibly even less next year and during the rest of the eighties, new records for production seem unlikely to be set anytime soon.

Behind these less-than-spectacular expectations for production and demand are lackluster forecasts for the major uses of these inorganics. Two of them—sulfur and potash—with more than 42% of estimated 1985 tonnage for all four, depend on ag-

inorganics have had large production declines with just partial recovery for four years, during which time pressure on selling prices has been severe, and returns on investment have been reduced to minimal levels. Such a situation provides little money for research and development investment.

As a result, new products, derivatives, and uses of these inorganics are few. No major new use looms now for any of these chemicals, with the possible exception of lime—which has the properties needed for many kinds of air, water, and solid waste pollution control.

Unless something unexpected occurs to change demand for these mineral inorganics, growth in production through the end of the 1980s will range in the 1- to 2%-per-year average. And phosphorus, because of a decline in its large hold on household detergents, may suffer a 1 to 2% annual decrease in production over this period.

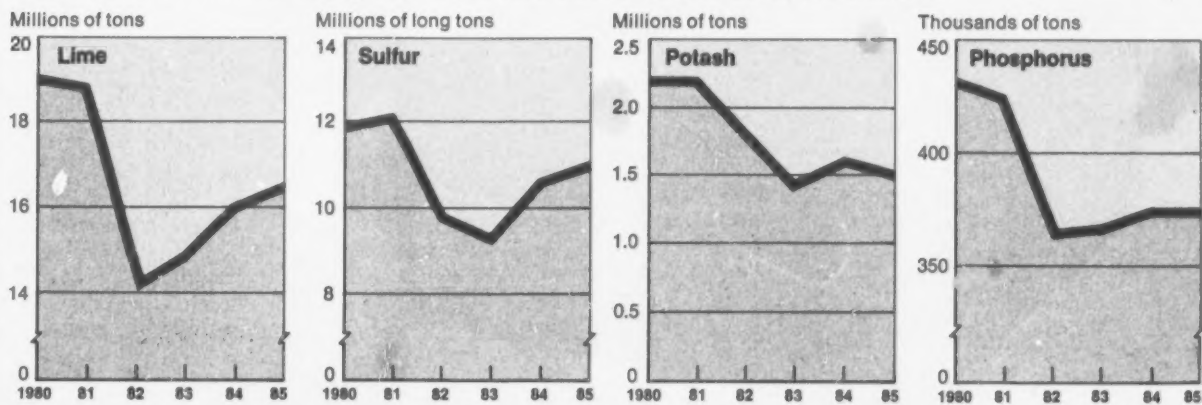
For details of the near-term outlook for these mineral inorganics, please see the following pages.

Key Chemicals

riculture for a very large share of their consumption, and agriculture is an industry clearly in financial trouble. A large part of the demand (not quite half) for the other two inorganics also goes to uses with little or no growth forecast for the next several years.

Producers of these inorganics naturally hope to gain new markets for their products, either directly or as derivatives. Unfortunately, these

Production of mineral inorganics recovers but remains below 1980 levels

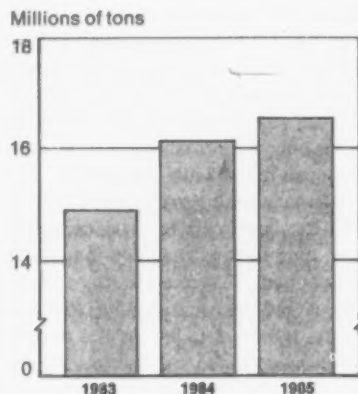


Sources: U.S. Bureau of Mines, Department of Commerce, C&EN estimates

Lime

- Demand growth slower
- Capacity in excess
- Prices weak but holding

PRODUCTION



Note: No capacity estimates are available.

MAJOR PRODUCERS

Chemical Lime, Dravo Lime, Genstar, Marblehead Lime, National Lime, U.S. Gypsum

HOW MADE

Calcining limestone to make quicklime, CaO-MgO, then adding water to make hydrated lime

MAJOR END USES (U.S.)

Metallurgy (mainly steel) 40%, pollution control and wastewater treatment 15%, chemicals 10%, potable water treatment 10%

FOREIGN TRADE

Exports—tiny and holding at about 20,000 tons, imports—small and declining to about 200,000 tons

PRICES

\$50 to \$55 per ton, list, with variations for volume, type, and plant location

Lime producers have reason to expect an increase in their total output in 1985 to about 16.5 million tons. At that level, production will not be near the recent historical high of some 21 million tons in 1979, but it will be substantially above the recession low of about 14 million tons in 1982.

This year's production of lime—one of the oldest chemicals known to man—will be up about 400,000 tons, or about 2%, from production in 1984. That incremental gain will be much smaller than last year's, resulting from the continuing shift in uses of lime. Major long-term uses in the metallurgical field are expected to decline again in 1985, but this drop will be more than offset by increased use in construction and in pollution control. Both of these lime uses also will continue to grow relatively fast, giving hope to producers who recently have had severe problems from excess production capacity.

No estimate of total plant capacity is available for lime production because of the diversity of producers and because of the relative ease with which plants can be shut down and restarted. Some plants have been down for several years now, because of declines in metallurgical demand by steelmakers during the 1980s. The Bureau of Mines reports that 137 plants produced lime during all or part of 1984, down from 154 plants in the 1979 peak. The average operating rate of these plants in 1984 was well below that in 1979.

The lower lime-plant operating rate results in part from the problems in demand for steel. About 20% of lime production is captively used, with a big share of the captive lime used as a fluxing agent in steelmaking. During 1985, steel mill operating rates have slipped after rising last year, leading to lower estimates for that use of lime.

Besides steelmaking, the other big metallurgical use of lime is in processing copper ores, bauxite, and other nonferrous metal ores. Copper pro-

duction, in particular, has declined rapidly, which has hurt overall demand for lime.

The fastest growing uses for lime are in the environmental area. About 10% of total lime use goes to treat water in preparation for potable uses and another 15% of the total is used for various kinds of pollution control. The latter includes sewage treatment, acid mine water drainage neutralization, and sulfurous gases removal.

Stack gas scrubbing, however, keeps growing quite rapidly and will require some 1.25 million tons of lime this year. The future for this use of lime could be very bright, if addition of scrubbers measurably alleviates acid rain by reducing sulfur gas emissions from power plants and other plant stacks. Addition of wet or dry scrubbers to existing power plants could be expensive and operating costs high, so efforts are under way to develop burners through which hydrated lime is injected in preference to limestone. This is because lime's relatively greater surface area improves reactivity.

Still other new and large potential uses for lime in pollution cleanup could result from tests under way in Ohio to use lime to neutralize and coagulate waste pickle liquors containing oils now lying in pits. The dewatered product would go to a landfill.

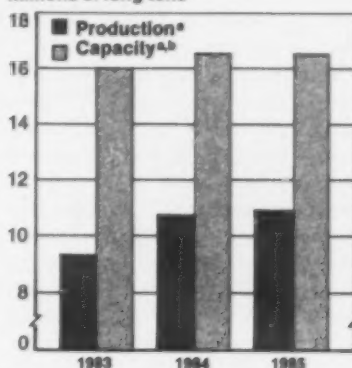
The other major uses of lime will contribute to demand growth this year as they offset declines in the metallurgical use, but none will show very rapid growth. Chemical manufacturing has become a very diverse use with the various individual uses varying from year to year. A sizable decline in one area of this use will occur this year, when the last synthetic soda ash plant is closed down. Pulp and paper manufacture takes about 1 million tons a year of lime as makeup, in addition to large quantities recycled. Construction uses of lime could be up because of more soil stabilization for road building, and increased use as an antistripping agent in asphalts.

Sulfur

- **Production holding**
- **Capacity level steady**
- **Prices may rise**

PRODUCTION/CAPACITY

Millions of long tons



^a All sources. ^b First quarter.

MAJOR PRODUCERS

Exxon, Freeport Minerals, Pennzoil Sulphur, Shell Oil, Texasgulf

HOW MADE

Melted from underground deposits; recovered from sulfur compounds processed in refineries, natural gas processing plants, and smelters

MAJOR DERIVATIVES (U.S.)

Sulfuric acid 90%, chemicals 5%

MAJOR END USES (U.S.)

Fertilizer 60%, chemicals 20%, metals recovery and processing 5%, petroleum refining 5%

FOREIGN TRADE

Exports—may decline to 1.2 million long tons, imports—may hold at 2.5 million long tons

PRICES

\$147.50 per long ton at Tampa, after discount

Sulfur production gains have about run their course for 1985. A good spring fertilizer season pushed production of sulfuric acid, but for the entire year production of sulfur will do well to increase marginally over 1984 to about 10.9 million long tons. Prices for sulfur continued to increase early in 1985 after a good boost in 1984, suggesting a possible tightening of supplies. But now, economics of demand for major sulfur-containing products—fertilizers and other chemicals—seem to be more important in sulfur pricing than does supply.

There are major reasons why sulfur output has shifted from good growth to almost no gain. This year, because of predicted lower exports of fertilizers, production of phosphoric acid used mainly in the making of fertilizers is forecast to decline. A lower phosphoric acid production would reduce the need for sulfur some 200,000 to 300,000 long tons. Exports of sulfur also are likely to decline 5 to 10%, or possibly as much as 100,000 long tons. The reduction in aboveground inventories of Frasch sulfur will continue, although probably at a somewhat slower rate than in the past two years.

An involuntary decline also will occur in recovered sulfur production in 1985. Refinery and gas-processing operations have been restricted during the first half of this year because of slack demand and because of imports of fuel products. That situation, in January, for instance, caused Frasch sulfur production to exceed recovered sulfur output for the first time in more than two years.

Increased use of sulfur in the nonfertilizer manufacturing area, such as chemicals manufacture, will offset the expected decline in demand for making fertilizers. And imports of sulfur also might decline slightly, perhaps about 100,000 long tons, thereby reducing the potential supply. Lowered imports would have to be made up by increased domestic production.

Meantime, sulfur capacity has gone on hold. Additions to capacity to recover sulfur from crude oils and natural gas are being offset by shutdowns of similar capacity, as refining declines and some gas fields are depleted.

Capacity utilization in sulfur production means little because capacity to recover sulfur from hydrocarbon streams is purposely overbuilt to ensure that the sulfur is removed to prevent air pollution. Estimates of capacity to produce sulfur by the Frasch process also are approximate, because sulfur-bearing formations vary in their response to hot water injection.

Capacity estimates of 16.5 million long tons per year to produce sulfur from the various sources could be understated, if the sources are more fully utilized. Full utilization would mean full operations at refineries and at gas-processing plants, maximum (despite the economics) injection of water at Frasch operations, and full operation of the various kinds of smelters. Small additional quantities could be obtained from pyrites, miscellaneous ores containing sulfur, and industrial production of various sulfur-containing gases.

Concern about a shortage looming soon for sulfur may be unwarranted. Relatively large stocks of sulfur are above ground in vats in both the U.S. and in Canada. For economic reasons, these stocks can be reduced to meet demand without an increase in production.

However, longer term, the currently producing Frasch sulfur deposits will become depleted, and major Frasch producers have extensive exploration programs under way for economically suitable new deposits. As part of the continuing search for petroleum supplies, additional sour gas is becoming available as a source for sulfur.

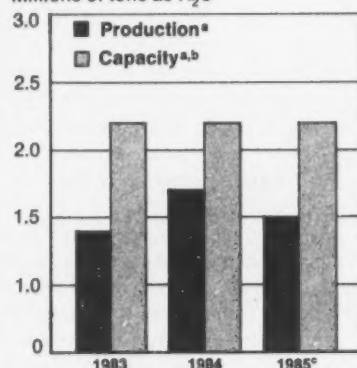
For all of 1985, demand for products using sulfur or made from sulfur may remain about even with last year's. Total demand, however, will remain strong and will keep sulfur prices relatively high.

Potash

- **Production to decline**
- **Capacity partly closed**
- **Prices weak**

PRODUCTION/CAPACITY

Millions of tons as K₂O



^a All forms. ^b First quarter.
^c More than 25% capacity shut down.

MAJOR PRODUCERS

AMAX, IMC, Mississippi Chemical, New Mexico Potash, Potash Corp. of America, Texasgulf

HOW MADE

Shaft and solution mining of potassium salts, mainly the chloride, and subsequent purification; recovery by evaporation of brines

MAJOR END USES (U.S.)

Fertilizer 95%

FOREIGN TRADE

Exports—may decline to about 500,000 tons, imports—holding at about 5 million tons

PRICES

About \$100 per ton, list, depending on type and salt

The U.S. potash industry seems to be set for some changes. Production this year may drop more than 10% from last year, and operating capacity likely will decline a like amount. In addition, some of the mines in New Mexico have changed ownership, and more changes are rumored to be in the works.

Potash production this year likely will be about 1.5 million tons, reported as K₂O. However, variables such as weather, farm economics, the size of inventories, and prospects for next year can add to or subtract from this estimate. The best or the worst conditions would increase or decrease production about 200,000 tons.

U.S. production of potash falls far short of consumption, with the difference made up by imports from Canada. In 1984, about 6.1 million tons of potash were consumed, 95% of which was used as fertilizer. The other 5% was consumed in making a wide variety of chemicals that require the potassium atom. Most of this, some 5 million tons in 1984 with the same amount forecast for 1985, is Canadian imports, which have been coming to U.S. markets for a long time. In 1980, imports of just less than 5 million tons accounted for 78% of the slightly higher consumption of 6.35 million tons. Imports slipped by more than 1 million tons in 1982, to 3.9 million tons, as total consumption dropped 1.2 million tons. Imports, as well as total consumption, climbed back to historical levels as the payment-in-kind program was completed in 1984.

Logistics play a part in what may seem to be a large volume of imports in relation to consumption. U.S. exports this year are estimated to be some 500,000 tons of potash, a volume that could have been used in place of part of the imports. However, the vast majority of U.S. potash production is in eastern New Mexico, far from areas of high consumption, but relatively closer to ports that can service sales to South America and other

areas at lower cost than can potash produced in Canada.

Because of the strong U.S. dollar compared to Canadian currency, Canadian production—some by U.S. companies operating in Canada—and Canadian exports to the U.S. cost less than U.S. product. Transportation distances also aid sales from Canada.

The poor economics of potash production in New Mexico have existed for years, with mines and mills there being shut down from time to time. The most recent was Kerr-McGee's decision to shut down and sell its New Mexico operations. At one time, Kerr-McGee had 600,000 tons of potash capacity there. The company took a \$24 million write-off on these operations and sold them to New Mexico Potash in April of this year.

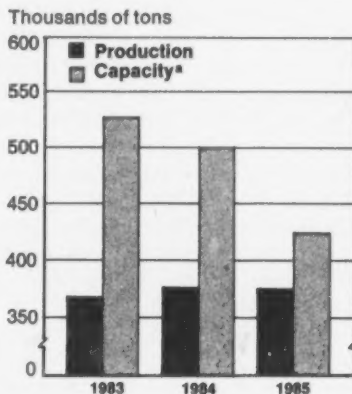
New Mexico Potash, a wholly owned subsidiary of Vertac Chemical of Memphis, announced that it would operate one of the two processing facilities it acquired with a capacity of 300,000 tons per year. Part of the production is used captively by Vertac at its plant at Vicksburg, Miss., where it makes potassium nitrate.

Although not all results are in yet for fertilizer demand for this spring season, early indications are that the large inventory of potash built up during the second and third quarters of 1984 have been drawn down. However, this inventory drawdown so far hasn't helped the depressed prices for potash very much, if any, according to one industry source. Producers may try to keep inventories down by holding down production this summer until they can determine the size of crops produced this year, farm commodity prices, and prospects for fall fertilization and 1986 spring consumption, the source adds. If prospects seem to be good, then potash production may be increased some in the fourth quarter, making the early forecast of a production of 1.5 million tons a bit low. A somewhat higher production, however, probably won't do much for prices.

Phosphorus

- **Production flat**
- **Capacity reduced**
- **Prices holding**

PRODUCTION/CAPACITY



■ First quarter.

MAJOR PRODUCERS

FMC, Monsanto, Occidental, Stauffer

HOW MADE

Reduction of phosphate rock in electric furnaces with carbon (coke) and silica as aids

MAJOR DERIVATIVES (U.S.)

Phosphoric acid and derivatives 85%, other chemicals 10%

MAJOR END USES (U.S.)

Detergents and cleansers 45%, metal treatment 15%, foods and beverages 10%, chemicals 10%

FOREIGN TRADE

Exports—expected to hold at about 20,000 tons, imports—negligible

PRICES

91 cents per lb, list

Phosphorus producers this year will have the best capacity utilization rate among the major-volume mineral inorganics. Although actual production will be up marginally, if at all, from last year, use rates will be up because electric furnace phosphorus capacity has dropped 20% in the past two years.

A good plant operating rate, however, doesn't mean that all is well with the phosphorus industry. The reduction in capacity during the 1980s clearly indicates that this industry has had and continues to have problems. The production estimates for 1984 and 1985, at 375,000 tons, are up less than 5% over the recent historical low of 361,000 tons in 1982.

However, production this year may not even reach 375,000 tons, depending on demand by the major uses such as detergents and cleansers, metal treating, and foods and beverages. Estimates of reported output by the Department of Commerce for the first quarter total just over 100,000 tons, but this production may be high for seasonal reasons.

The chance that phosphorus production will return to 1980's level or higher seems slim. The 1980 production total of more than 430,000 tons exceeds some current estimates of nameplate capacity. Thus, new plants would be needed to produce even 400,000 tons. Equally slim is the likelihood that new plants will be built at today's production economics. Low selling prices of elemental phosphorus and the derivatives made from the acid from this phosphorus will not allow construction.

Manufacture of detergents and cleansers dominates the electric furnace phosphorus uses at about 45% of domestic consumption. Most of the thermal phosphoric acid used in detergents and cleansers is made into sodium tripolyphosphate (STPP). This use of thermal phosphoric acid in the U.S. differs from the situation in most other countries where wet-process phospho-

ric acid is used in making STPP. Small amounts of wet-process acid, however, are used in STPP in this country.

The problem for producers of phosphorus and of STPP is the expanding regional bans on use of phosphate builders in detergents. The bans aim at reducing water pollution. For example, a prohibition on detergent phosphates has been passed in Maryland and one might be passed in the next legislature in North Carolina. Removal of a ban on phosphate in Dade County, Florida, has helped in a small way, but not enough. Some Great Lakes states have banned sale of phosphate-containing detergents, and others are expected to do likewise.

STPP and other phosphoric acid derivatives also go into a variety of household, industrial, and institutional cleansers, many of which are formulated for specific uses. Their consumption changes as they move in and out of favor with new formulations and new advertising campaigns. Growth of these products continues to be small and will have no significant effect on demand for phosphorus this year.

Metal treating ranks next in volume to detergents as a consumer of phosphorus, but it is a distant second accounting for about 15% of total consumption. Use in metal treating—most of which is in the automobile industry—will have little, if any, effect on changes in consumption of phosphorus this year. Down-sizing of cars and a shift in style away from bright metal trim indicate that this use likely will not grow much this year and will leave demand substantially lower than at the beginning of the decade.

Food and beverage uses of thermal phosphoric acid grow at about the same rate as population growth. Shifts in fashion and diets change the pattern of individual products' consumption of phosphoric acid and derivatives, but the net growth remains small and is not enough to do much more than offset a minimal part of the declines in other uses.

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Scientific Freedom

Universities' concerns about national security controls ease

Page 7

News of the Week

■ **National security officials seek to limit access to supercomputer centers much to chagrin of NSF and university professors.** Page 4

■ **West Germany's BASF makes a bid for American Enka, fibers unit of Akzo.** Page 5

■ **Environmental and conservation groups call for global outlook in solving pollution problems.** Page 5

■ **House subcommittee passes its version of Superfund bill.** Page 6

■ **Technique identifies new infrared emission lines of hydrogen species.** Page 6

Cover: Photo by Stacy Pick/Uniphoto

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Business

Yearly increases in U.S. chemical firms' health care costs have been lowered considerably but more cost-containment measures will be needed to keep up with rising medical care costs. Page 13

Worldwide overcapacity of ethylene glycol will lead to battle for share of market that is shifting toward Asia. Page 16

Government

Stricter bills regulating chemical pollutants in drinking water pass in both the House and the Senate. Page 19

House reverses itself and votes funds for manufacture of new binary arms as a result, in part, of intense lobbying. Page 20

Technology

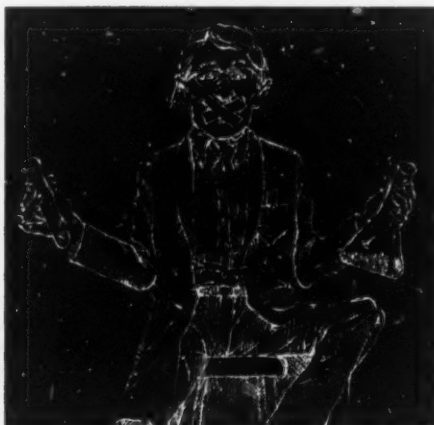
Pulverized coal, peat, or biomass oxidized with nitric acid under mild conditions gives a fuel similar to diesel fuel. Page 23

Nobel Laureate Paul Flory honored by international symposium on polymer science held on his 75th birthday. Page 24

Bats made of graphite-reinforced thermoplastic combine lightness and durability without annoying ping of aluminum club. Page 25

Books

"The Mystery of Life's Origin" assesses theories and research in chemical evolution from a creationist viewpoint. Page 26



News Focus

Academic researchers no longer are threatened by government control of information exchange, but purveyors of technology with both military and commercial applications are being restricted. Page 7

Chemical Industry's Health Care Benefits Likely To Change Further

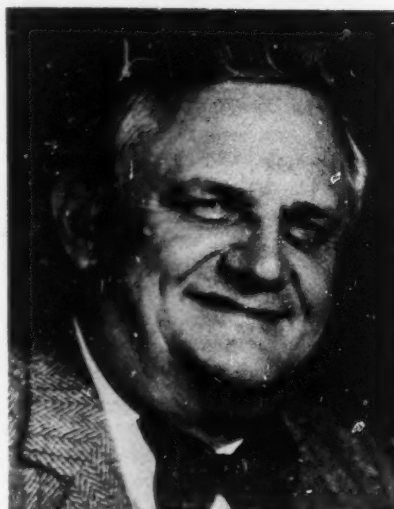
Firms' medical expenses are rising more slowly now, but increase in cost-containment measures is foreseen; new retirees face changes, too

David Webber, C&EN New York

With some carrots and many sticks, chemical companies have induced employees over the past few years to accept changes in their health care benefit packages that would have been unthinkable to many of them five years ago.

Citing the need to slow the rate of medical care inflation, much of the industry has eliminated traditional benefits like coverage for hospital stays from the first dollar on and has given employees financial incentives to use less-expensive alternatives to in-hospital treatment. Since doing so, most firms say, they have experienced smaller annual increases in their health care benefit expenses.

But, companies say, as welcome as these results are, the measures adopted so far may not be enough. Although firms have benefited from the shifting of a portion of their expenses to employees through deductibles and other cost-sharing devices, medical care costs in the U.S. are still rising at double the rate of the consumer price index. Furthermore, how much of the slowdown in the growth of corporate medical benefit bills is due to the cost-containment measures instituted so far and how much to the past four years' deceleration of overall inflation is open to question. For that reason, many companies seem to be contemplating further changes in their health care benefits programs,



Wetzel: second opinion provisions

all designed to mold employees into what has sometimes been called "better health care consumers."

Judging from the plans of 10 major chemical producers surveyed for this report, companies have completed—or at least set in motion—the bulk of whatever shifting of costs from themselves to employees they wish to accomplish. The argument for cost sharing is that employees and their dependents will select health care services more carefully if part of the fee comes out of their pockets. That logic has proved itself essentially correct. Now many companies intend to focus on producing subtler changes in their employees' health care utilization patterns. The goal will be greater use of such alternative forms of health care delivery as outpatient surgery, home care, birthing centers, and the like. The means will be a greater emphasis on such carrot-and-stick combinations as second opinions for certain surgical procedures and precertification—by benefit plan administrators or company medical de-

partments, or both—of the need for a hospital stay.

Action began to be taken by both the government and many industries in the early 1980s in an effort to get health care costs under control (C&EN, June 27, 1983, page 6). The government's medicare and medicaid costs were ballooning wildly, and industry's health care benefit expenses were making up an increasingly noticeable percentage of net income. Americans were using medical services more each year, a trend that was seen leading doctors and hospitals to run bills up with superfluous procedures and protracted hospital stays. The portion of the gross national product made up of hospital bills alone had risen to nearly 4%.

Today there is broad evidence that the efforts made by both companies and the government to check medical care inflation have paid off. In 1984, the number of hospital admissions dropped 4% from the year before. Hospital occupancy rates fell 8%, and the average length of stay declined 4%. Hospitals' share of GNP has moved down to 3.4%. The annual increase in medical care costs, according to the Labor Department, has slowed from 12% in 1982 to 9% in 1983 to 6% in 1984. Over the first three months of 1985, the index was up just 4% over the 1984 average.

Most chemical companies have benefited from this reversal of the long-term trend. Dow Chemical, for example, made a major change in its employee health care benefits plan last October, leaving employees the choice of retaining the old first-dollar coverage, albeit with steadily rising employee premiums, or enrolling in a new comprehensive plan in which employees share costs but pay a much lower premium. The pattern of Dow's annual

medical benefit expense increases suggests that the new plan is working: After year-to-year growth of 15% in 1980, 9% in 1981, 14% in 1982, and 12.5% in 1983, Dow's health care benefit expense rose just 6% last year. The company expects a similar increase in 1985.

Because general inflation was slowing during the same period, it is difficult to determine how much of the credit for decelerating corporate health care expense growth belongs to plan changes, but examples from other firms that have changed their plans offer evidence that cost sharing and other new plan features have had an impact. At Air Products, which changed its plan last October, the corporate medical bill grew at a 17% annual compound rate between fiscal 1979 and 1984, says Raymond A. Glennon, manager of employee benefits. In fiscal 1985 (ending Oct. 31), he expects an increase of just 5 to 6%.

Ethyl, after implementing cost-containment measures in January 1982, watched growth of its health care bill drop to 16% in 1983, 12% in 1984, and, if estimates are correct, the company's expense will actually decline this year nearly 9%. Hercules was paid back for its July 1983 benefit revision with a net decrease in its medical care bill of somewhat less than 2% in 1984, according to Fred Laquinta, manager of benefits planning. And at Rohm & Haas, the optional cost-sharing benefit package has been so cost effective since its inception in 1983 that, beginning this year, the company stopped charging employees in the new program any health insurance premium.

The experience of Monsanto offers some comparison. Although the company has implemented incentives—some voluntary and some not—for employees to use cheaper alternatives to hospitals, there has been no addition to cost sharing. Between 1980 and 1985 (estimated), the company's medical benefits bill will grow at a compound rate of 12% per year, says Elizabeth J. Hawk, manager of compensation and benefits.

"The increases have slowed somewhat in recent years, but primarily because general inflation slowed and

Health care cost-containment measures have slowed the rate of increase of hospital costs

Fostered chiefly by fixed Medicare fees but furthered by corporate changes in health care benefits for employees, the rate of increase of hospital costs in the U.S. has slowed considerably since 1983. Hospital costs rose just 4.5% in 1984, the smallest annual increase since 1963 and well below the 10% rise recorded in 1983, according to the American Hospital Association. For the first time in more than two decades, hospitals' portion of the gross national product declined—to 3.4% last year from 3.6% in 1983.

Several changes in long-term trends brought about the hard braking of hospital cost growth. Most significant, fewer people checked into hospitals. After peaking at about 38 million patients in 1982, admissions dropped in both 1983 and 1984, decreasing about 1.5 million in 1984 alone. As a result, the hospital occupancy rate fell to 67% in 1984, and the average length of time patients stayed in hospitals declined to 6.7 days, the first time the average stay has been below seven days in more than a decade.

At the same time, the number of outpatient visits to hospitals grew a modest 1.1% to more than 232 million in 1984. That development reflects both the need for hospitals to keep costs within fixed reimbursement limits for Medicare and Medicaid patients, and the combination of financial incentive and persuasion with which corporations have prodded employees into using outpatient services over hospital admission whenever possible.

In fact, ambulatory surgery, one of the chief elements of outpatient health care, ranked first among corporations as a strategy to control health care costs last year, according to an AHA-sponsored survey of 200 of the nation's largest industrial firms. Among

the other most important strategies cited in the survey were other alternatives to in-hospital procedures such as preadmission testing (to shorten the length of a hospital stay); utilization review programs (to check hospital and doctor bills); second-opinion programs; home care; and preadmission review (to determine the necessity of admission). The companies also said they had saved significantly through greater cost sharing with employees and self-insurance programs.

More specifically, more than a third of the firms require employees to get a second opinion before elective surgery, and most of those assess a penalty if an employee fails to do so. A third of the firms negotiated contracts with unions last year, resulting in additions to health care benefits 36% of the time compared to reductions in benefits just 19% of the time. Nevertheless, coinsurance amounts (the percentage of medical charges an employee pays after exhausting his or her deductible) were increased in 41% of the new contracts. The survey also found that 80% of the companies surveyed are now self-insured.

Despite the slowing down of health care inflation by the above measures, however, medical care costs continue to outpace the consumer price index. In 1984, for instance, the medical care price index (supplied by the Department of Labor) rose 6%, down nicely from a 9% increase in 1983 and a 12% increase in 1982. But those rates were still far higher than those for the consumer price index, which rose 3% in 1984, 3% in 1983, and 6% in 1982. That is why some chemical companies, though pleased with the progress made so far, believe further steps will have to be taken to keep health care costs under control.

	Hospital admissions	Occupancy rate	Average stay (days)	Outpatient visits
1984	36,198,537	66.6%	6.7	232,190,313
1983	37,691,924	72.2%	7.0	229,557,530
% change	-4.0%	-7.8%	-4.3%	1.1%

Note: Figures are for all U.S. community hospitals (excludes specialty and single-service hospitals); figures adjusted for leap year 1984. Source: American Hospital Association

because of the fledgling competition in the health care marketplace," she says. "The fact is that the trend is still way too high and is expected to return to double-digit levels."

Whichever change—in inflation or in benefits provisions—most accounts for the slower growth of corporate medical benefit expenses, most benefits managers believe further steps will have to be taken. "There are still things we haven't done," remarks Edward A. Howes, manager of employee benefits planning at PPG Industries. As medical costs continue to rise, for instance, the company might raise employee premiums, deductibles, and co-insurance (the percentage of fees paid by the employee after the deductible is exhausted).

"Yes, there will undoubtedly be more changes," says Hercules' Laquinta. "We are seeing the creep of health care inflation again. In a year or so, we will take the next step." New provisions might include precertification for nonemergency hospitalization, concurrent reviews of hospital stays, and "large-case management," in which a team of doctors, hospital administrators, and other experts would be convened to weigh the options for employees needing expensive treatment. "That's inevitable," he says of the last item.

Monsanto, says benefits manager Hawk, is looking at other ways to stem the double-digit annual increases still being absorbed there. "There is no firm plan yet," she says, "but we know we can't continue to accept this trend." Similarly, Dow Chemical is considering various possibilities, although nothing further is planned now.

To a certain extent, chemical companies have entered a phase in which they are fine-tuning their employee health care benefits plans. They are not absolutely certain yet which aspects of the new programs are most cost effective—both because of the clouding effect of the downward trend of inflation and because, at many companies, large numbers of employees are still gradually shifting from traditional coverage to the new plans. Still, many benefits departments have a far better idea now of where their health care dollars are going than

they did at the beginning of the decade.

The chief reason is a widespread upgrading of computerized analytical systems for benefits administrators. For example, Du Pont's manager of benefits and health care William C. Deans admits that the company previously had no comprehensive data system with which to track its medical spending. Now, he says, the company analyzes its expenses on a quarterly basis.

"Now we can begin to understand what we're paying for," he says. The company structures some of its analysis according to the diagnosis-related groups formulated by the government to control reimbursement for medicare. In this way, Du Pont is able to quantify the percentage of its medical spending that goes for hospital room charges, for pharmaceuticals, for testing, and for other major categories.

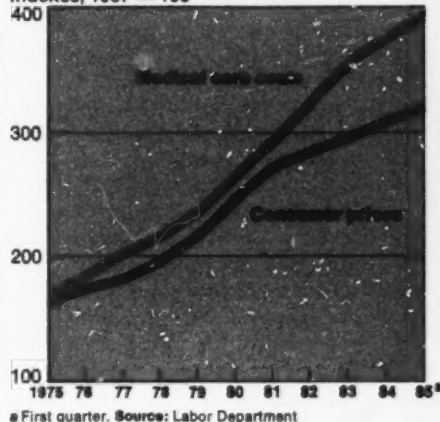
Better data analysis can enable administrators to refine their plans in the future, companies say. Air Products, for instance, has placed a much greater emphasis on gathering data on the utilization of its benefits since changing plans last October. "It is now one of the most important parts of the operation," comments Raymond Glennon, "answering the question: Where are the dollars being spent? I would like to be in a position to identify the cost-effective health care providers, and then, through plan design, use the plan to get employees to use them."

At the least, companies are finding, enhanced data analysis can serve to justify the changes already made. Hercules' Laquinta points out that computer modeling comparing the company's revamped medical benefits program to its former one showed that Hercules would have spent 17% more in 1984 than in 1983 under the old system.

With this greater ability to locate the leaks in their benefits programs, companies now plan to make greater use of second opinions for nonemergency surgery and precertification to steer employees into greater utilization of outpatient health care. Many chemical company benefit plans already include voluntary versions of a second opinion feature; some have made them mandatory.

Medical care costs still rising faster than overall inflation

Indexes, 1967 = 100



Since the first quarter of this year, Monsanto has been requiring a second opinion before approving coverage for a group of 14 surgical procedures. Dow has been doing the same since last October, both for those employees who have signed up for its new cost-sharing plan and for those who have remained in the old first-dollar plan. Rohm & Haas' employee benefits department, which already has inserted mandatory second opinion provisions in some union contracts, plans to recommend the same requirement to senior management for all salaried personnel, says corporate supervisor of employee benefits Ron Wetzel.

Potentially more controversial is mandatory precertification processing. In general, such a provision would require an employee whose hospital admission for a nonemergency procedure had been ordered by a physician to submit his or her case in advance for review. In most cases, a first screening by a registered nurse would be enough for approval, companies say, but if the nurse questioned the need for the operation, the case would be passed on to a physician or some other higher-ranking review board.

Companies have been reluctant to institute precertification because, unlike cost-sharing devices, it is seen in some camps as an intrusion by the employer into the physician-patient relationship. As Rohm & Haas' Wetzel remarks, there is a cer-

tain "Big Brother" aspect to such a provision.

Still, many benefits administrators believe precertification is a necessary next step in controlling medical spending. "We are coming to the conclusion that it would help employees contain costs," says PPG's Howes. "And they do have to be mandatory. There are not enough savings when they are voluntary."

Air Products has approached precertification in a gingerly fashion, setting up an on-site nurse/coordinator at its Allentown, Pa., headquarters with a combination precertification/consumer awareness counseling function. For most admissions, says benefits manager Glennon, precertification is not necessary. It is required if an employee is applying for such newer benefits as hospice, drug or alcohol abuse center, or home health care.

The real value of precertification programs—especially if combined with utilization review (examination while a patient is in the hospital of the procedures ordered and the length of stay)—may not lie so much in individual cases, comments Rohm & Haas' Wetzels. Instead, it may lie in cultivating an environment in which physicians know that their decisions will be subject to peer review.

As companies enlarge their role in reviewing the need for employees to undergo certain medical procedures, they also may face difficult decisions about which types of very expensive operations they will cover. Many firms already exclude many nonemergency "cosmetic" procedures, such as radial keratotomy (surgery to correct near- or farsightedness). But determining which procedures to cover in "life-and-death" situations may become more troublesome as advances in medical technology make possible operations, such as liver transplants, that may cost hundreds of thousands of dollars. The number of organ transplant operations especially is expected to increase as organ donor programs are refined. Because many such operations are considered experimental now but, because of swift medical advances, may become recognized as standard procedure by the medical community within a rel-

atively short time, there is a gray area in which some fine distinctions must be made. In some cases, the gray area is made even grayer by disagreement on which procedures should be considered experimental. There is no single body that decides; generally, it is up to the insurance carrier.

To deal with the possibility of tremendously expensive claims, some companies have instituted lifetime caps on coverage per participant in their medical benefits program. Air Products, for instance, has a \$500,000 lifetime maximum. "It can make you look cheap," concedes benefits manager Glennon, "but we think that our health care dollars are best spent at the front end, on measures designed to keep employees out of the health care pipeline."

Because many experimental operations—such as liver or artificial heart transplants—are still quite rare, most chemical companies have not yet had to make such decisions. And for the most part, companies are distanced from the decision-making process, leaving the determination to their insurance carrier, or, if they are self-insured, to an outside plan administrator. In any case, companies stress that in tailoring their benefits plans, they do not intend to deny beneficiaries any medical care they truly need.

"We won't strand an employee," says Du Pont's Deans.

Still, the campaign for cost containment is bringing companies into other uncharted waters. Chief of these is medical benefits for retirees. "The rate of increase has come down for active employees," points out PPG's Howes, "but we can't put the same controls on our retiree population. These costs are going way up. That is where the real concern is now."

Company efforts to restrain retiree medical costs encounter two stumbling blocks. First, recent court decisions prevent firms from instituting cost-containment measures in coverage for former employees already retired when plans were changed. And second, it is commonly believed—though no hard evidence yet exists—that many doctors and hospitals are shifting unrecovered costs stemming from the government's medicare reimbursement ceilings to the beneficiaries of private insurance programs. Since retirees tend to be heavier health care consumers, this effect has its greatest impact on the retiree population's claims.

Under these conditions, companies have made little change in retiree medical benefits, for fear of being taken to court. In general, however, they have altered the benefit program for employees retiring after the date of the plan change. For those retirees, the new cost-containment measures will apply. □

Global shakeout expected in ethylene glycol

"There is a war going on out there that only the fit will survive." That's how T. R. (Rick) Jones, vice president of Union Carbide Ethylene Oxide Glycol Co., describes the world ethylene glycol business today. Access to stable supplies of inexpensive feedstock, state-of-the-art technology, world-scale plants, and dedication to the business ultimately will determine who those survivors will be, he says.

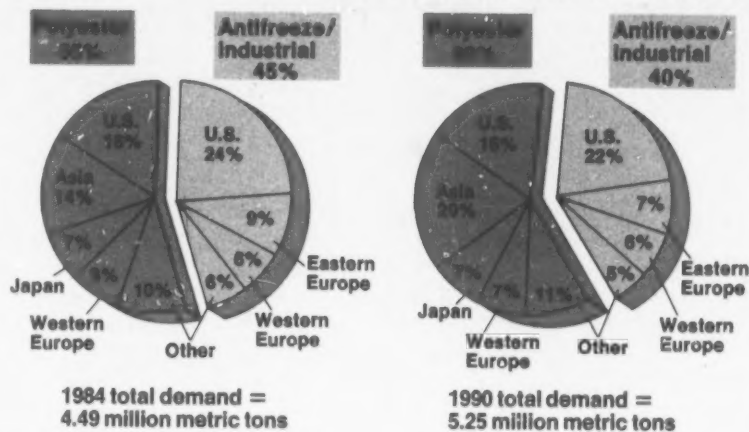
The ethylene glycol market is truly a world market, and it is the key to the ethylene oxide-glycol business. The oxide itself is used very little as a product. Instead, most of it goes to downstream derivatives, with the glycols accounting for

about 60% of the market. The remainder of the oxide goes into various other derivatives such as ethanolamines, glycol ethers, surfactants, functional fluids, and polyethylene glycols.

Glycol really has only three outlets—polyester, antifreeze, and a miscellaneous all-other category. Polyester is by far the largest market, consuming about 35% of all the ethylene oxide produced and about 55% of the glycol.

But that simplistic market breakdown belies an intense battle that is taking place for world market share. And it fails to reveal some important shifts in regional markets that Jones described at a recent

Biggest growth in ethylene glycol for polyester will be in Asia



Source: Union Carbide Ethylene Oxide Glycol Co.

petrochemical meeting held by the Corpus Group in Calgary.

Behind the market battle is a worldwide overcapacity in both ethylene oxide and glycol. This year, for instance, world oxide capacity is about 7.3 million metric tons. Demand, says Jones, will barely hit 6 million metric tons.

Union Carbide, with six ethylene oxide plants in North America, musters 18% of the world's capacity. Other major producers include Shell, Dow Chemical, Imperial Chemical Industries, BASF, and the BP group, with 5 to 7% each. Japan accounts for 9% of world oxide capacity, and newcomer Saudi Arabia already has a 5% share.

Another group of producers, which Jones calls the "one per centers," consists of 34 different companies that control 37% of world oxide capacity. In the battle for survival, many of these small companies, along with a few of the larger ones, will be too weak to compete.

Most of this capacity resides in North America and Western Europe. But demand, Jones says, is shifting away from these two areas. The fastest growing region is Asia.

Last year, for instance, the U.S. accounted for 40% of world glycol consumption. Western Europe took 14%, and Asia accounted for another 14%.

By 1990, the picture will be much different. Jones estimates that the world glycol market will grow from last year's 4.5 million metric tons to

5.25 million metric tons. That's about a 3%-per-year average growth rate. During that time, polyester will increase its share of glycol consumption from 55% to 60%, whereas antifreeze and industrial uses will decline to 40%.

The big difference, however, will be the huge shift away from North America and Western Europe toward Asia. As the world glycol market is growing an average 3% annually—about equal to gross domestic product growth—demand in Asia will increase 8% annually, says Jones. Asia's share of the world demand for polyester glycol in 1990 will jump to 33%—greater than that of the U.S. and much higher than Western Europe's 12%.

The big question is how this shifting demand will be satisfied. Ethylene oxide supply will continue to outdistance demand at least through the early 1990s. And Jones defines supply as "maximum attainable production," not theoretical nameplate capacity. He does not think that supply and demand will start to come into balance before 1993 or 1994.

It's inevitable, then, that rationalization will have to occur in the industry, Jones says. "Weak producers cannot continue to operate or they will bleed to death," he adds. Over the next few years, then, he expects about 1 million metric tons of capacity to be shut down throughout the world. That's a lot of capacity—it represents three or four

world-scale units. Jones believes that most of the plant closings will take place in Western Europe and in Japan. He bases his conclusion on a comparison of glycol economics there and in the U.S. (Gulf Coast), Canada (Alberta), and Saudi Arabia—all of which he calls resource-rich areas.

No one producing region has a dominant economic advantage over the others in every area of the world. But in Japan and Western Europe, all three resource-rich producers enjoy an economic edge even over local production. In those two areas, local producers' economics are poor because output is based on naphtha. That's why both Europe and Japan are logical candidates for plant closings. In Japan, the Ministry of International Trade & Industry (MITI) already has made plans to rationalize the ethylene oxide-glycol industry.

Thus, Jones believes that North America, which historically has been a net exporter, will continue to export. Western Europe, where supplies of ethylene oxide and glycol have been in excess, will have to rationalize over the next few years; it will become a substantial net importer of glycol by the late 1980s.

He also thinks that Latin America will become a net glycol importer and that Japan, after its plant scrapping exercise, will become a major glycol importer by the late 1980s. Asia has been an importer and will continue to be one.

By the end of this year, the Middle East and Africa will have become major exporters instead of importers. China, distinct from the rest of Asia, had a small net of glycol exports in the early 1980s but has become a net importer. If China builds its announced glycol unit, it will again become a slight net exporter to its Asian neighbors. Eastern Europe and the Soviet Union have and will continue to have an essentially balanced glycol situation.

The real glycol battle, says Jones, is not among the U.S., Alberta, and Saudi Arabia. It is between the resource-rich producers and the resource-poor producers. Eventually, he feels, the strong will prevail. But until then, industry profits will remain unacceptably low. □

DESCRIBE YOUR MOST RECENT OR CURRENT JOB
IF YOUR MOST RECENT OR CURRENT EMPLOYER IS NOT
AN A.C.A. INSTITUTION, GO TO SECTION IV.B. ON THE
BACK PAGE.

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NEWS

\$AL ARY \$UR VEY

BASE ANNUAL SALARY from PRINCIPAL
March 1, 1985. (DO NOT INCLUDE pay for
second job, overtime work, summer teaching, or
supplemental earnings or employment.) If zero, please
indicate.

\$ 39500 per year
If \$100,000 or more, please check here

c. SUPPLEMENTAL INCOME from PRINCIPAL
during calendar year 1984. (INCLUDE
bonus, overtime work, grants admin-
employer, summer teaching, or other
earnings.) If zero, please indicate

\$ 0000 per year
If \$100,000 or more, please check here

d. SUPPLEMENTAL INCOME from OTHER
WORK during calendar year 1984. (INCLUDE
second job, consulting, contract in-
employment in your profession.)

\$ 1000 per year
If \$100,000 or more, please check here

PLEASE EVALUATE THE FOLLOWING
INDICATE WHETHER YOU AGREE

e. My employer pays me
employees who have
Strongly agree
Agree
No opinion
Disagree

f. My employer provides for PRO-
fessionals within my
experience.

Strongly agree
Agree
No opinion
Disagree
Strongly disagree

g. My employer provides
advancement with-
in my field as good as the
equivalent qualifica-
tion.

h. Most of the time, I'm
Strongly agree
Agree
No opinion
Disagree
Strongly disagree

i. I feel that my job is secure for the next five years.
Strongly agree
Agree
No opinion
Disagree
Strongly disagree

ii. High school
Medical or professional school
College or university where the highest degree
offered in chemical science is:

Associate
Bachelor
Master
Doctor

My institution is a:
Associate
Administrator
Administrator
Administrator

Contracted tenure?

Contract is for a period of:
1/4 or less
1/3
1/2
2/3
3/4
full-time

Portion of your total academic year
devoted to:

1/4 or less
1/3
1/2
2/3
3/4
full-time

Principal professional activity during
1984?

Research or study
Daily/academic
Administration
Teaching
Academic employment
Other

STOP. YOU HAVE COMPLETED THE QUESTIONNAIRE.
PLEASE USE THE BLANK SPACE ON THE BACK
FORM FOR COMMENTS.

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CONGRESSIONAL INFO SERV-SKI
4920 EAST WEST HWY SUITE 600
BETHESDA MD 20814

News of the Week

■ Wall Street analysts see an increase ahead in chemical prices but chemical makers aren't so optimistic. **Page 6**

■ Witco Chemical found guilty of violating age discrimination act in suit involving 1983 firings. **Page 7**

■ A fifth supercomputer center has been set up—Carnegie-Mellon, University of Pittsburgh, and Westinghouse Electric. **Page 7**

■ National Library of Medicine's TOXNET, computer-accessed system to retrieve data on toxicology, is now available. **Page 8**

■ Counsel for former Hoffmann-La Roche employees suing the firm for age discrimination may add breach of contract to the charge. **Page 8**

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Business

Pfizer's Laubach looks at role of President's Commission on Industrial Competitiveness in high technology's future. **Page 10**

Biotechnology stock prices have surged back, although the rebound has been somewhat selective. **Page 14**

International Business

Indian and U.S. labor activists are trying to draw international attention to plight of Bhopal disaster victims. **Page 16**

Global environmental objectives were adopted at recent meeting in Paris of environmental ministers from OECD and EEC. **Page 17**

Government

Murder in the workplace: Illinois court decision against three U.S. corporate officials may spur similar prosecutions. **Page 24**

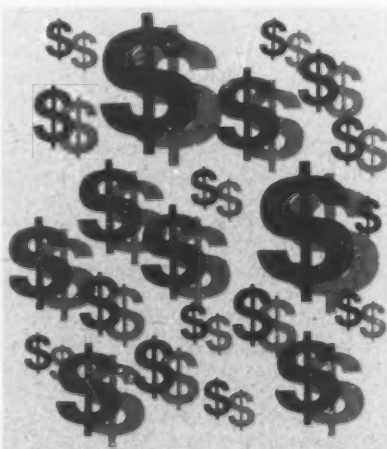
Science

Rocket launched to rendezvous with Halley's comet next spring will beam back valuable scientific information. **Page 27**

Electrolytic reduction of carbon monoxide to methane achieved by scientists at SRI International. **Page 29**

ACS News

Recent mass firings of chemical professionals reflect relatively harder economic times in the industry. **Page 40**



Salary Survey

Chemists are holding their own in salaries and employment this year. **Page 30**

Biotechnology stocks regain lost ground

Jaded with the promises of biotechnology-based companies, investors turned a cold shoulder to many of the gene splicers and antibody makers last year. Stock prices tumbled throughout the industry. At the end of 1984, C&EN's biotechnology stock index, which tracks the stock market performance of 12 firms representing a cross section of the biotechnology-related industry, was about 30% below its late 1983 level.

Then something happened. The year turned, and perhaps following some idea that a new year calls for a new look, the market regained its enthusiasm. Whatever the reason, biotechnology stock prices surged. Between New Year's Day and the end of February, the biotechnology stock index rose nearly 50%. Since then, excluding a slump during the first half of March, it has remained more or less on the plateau reached during the first two months of the year.

Unlike the 1984 slump, however, which was nearly universal, the rebound has been selective. Shares of Hybritech, for instance, which lost 15% of their value last year, are now worth 80% more than they were at the end of the first half of 1984. Other share prices are also far higher than they were a year earlier: Centocor, up 103%; Genentech, up 37%; Amgen, up 39%; and Genetic

Systems, up 28%. During May, the stock prices of Amgen and Hybritech hit all-time company highs, while Centocor closed the second quarter at a record high.

On the other hand, some companies' stock continues to languish. Shares of Monoclonal Antibodies, for example, are now worth 25% less than they were a year ago and have not increased in price since the end of 1984. In mid-May, the stock price hit a record low. The price of Collaborative Research stock is down 30% on an annual basis and has fallen slightly since the first of this year. Similarly, Molecular Genetics has lost value in the stock market this year; its June 28 share price was 34% below the year-earlier level. The price of a share of Bio-Response, on the other hand, though 23% below its year-ago level, has risen well since the beginning of 1985.

Continuing its nearly unbroken rise in the market is Applied Biosystems, which sells instruments and other supplies to biotechnology companies. Having risen 61% in value over the course of 1984, the company's stock split two-for-one at the end of March 1985; the price is now some 98% above its year-earlier level.

At the opposite end of the spectrum is Genex, which, buffeted by business reverses (C&EN, June 24, page 8), sank to an all-time low on

the stock market last month. Its price per share is now 68% below its year-earlier level. Much of the decline in the price of a share of Genex came after the stock market learned that the company would lose its sole customer for L-phenylalanine, its major product, after the current sales contract expires this October. During just the second quarter, the stock price dropped 48%, the ninth worst performance by any stock traded over the counter.

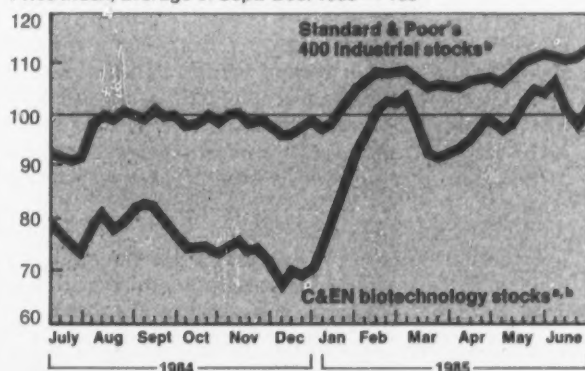
At the beginning of 1985, analysts predicted that the stock market would begin sorting out those companies with clear indications of substantial, near-term products and solid business plans from those that either seemed likely to remain development-stage companies for some time to come or failed to begin reporting at least token earnings. To a certain extent, investors have responded accordingly.

Hybritech, for instance, reported a 97% increase in revenues as well as net income for the first three months of 1985. Similarly, Centocor's revenues rose 77% in the first quarter with a rise in profit, and Amgen, although still reporting a net loss, posted an 89% jump in revenues. Genentech, although still without proprietary products, reported a first-quarter revenue gain of 32% and a net income increase of 86%.

David Webber, New York

Biotechnology stocks surged in early 1985, but lagged in market's 18-month growth...

Price index, average of Sept.-Dec. 1983 = 100



a Based on stock prices for Amgen, Applied Biosystems, Biogen, Centocor, Cetus, Damon Biotech, Genentech, Genetic Systems, Genex, Hybritech, Molecular Genetics, and Monoclonal Antibodies. b Reindexed to average for Sept.-Dec. 1983 period to show relative change. Prices as of Friday close each week.

... and individual stock performance was greatly mixed

Company	Latest price ^a	% change ^b	52-week range High Low
Amgen	8	39%	8 1/2 3 3/4
Applied Biosystems ^c	24	98	27 3/8 10
Biogen	7 1/2	-12	9 4 1/4
Bio-Response	6 3/4	-23	10 3/8 3 5/8
California Biotech	11 1/4	55	12 4 1/4
Centocor	18 1/2	103	18 1/2 8
Cetus	10 3/4	-5	13 1/8 8 5/8
Collaborative Research	4 1/8	-30	6 1/2 3 5/8
Damon Biotech	6 3/8	-12	7 3/8 4 1/8
Genentech	47 1/4	37	56 1/2 28 3/4
Genetic Systems	7 3/8	28	8 5/8 4 1/2
Genex	27 1/8	-68	13 2 1/4
Hybritech	25 1/4	80	26 1/4 11
Molecular Genetics	6 3/4	-34	10 3/4 6
Monoclonal Antibodies	9	-25	12 7 3/4

a As of close on Friday, June 28, 1985. b June 29, 1984, to June 28, 1985. c Adjusted for 2-for-1 stock split in March 1985.

Economic Status of Chemists Shows Modest Gains This Year

Salaries are up about 5%, nearly in line with rising living costs, and rate of unemployment has eased slightly from last year

The economic well-being of U.S. chemists has improved in the past year. A larger proportion of them are working full time than in either of the previous three years. And salaries are higher. The improvement, however, is slight at best.

The most recent survey of the employment status of members of the American Chemical Society shows that only 1.4% of them were unemployed but looking for jobs as of last March. That's the lowest rate of unemployment since 1981 and down

from 2.2% just two years ago. It's a rate that also is far below the 7.2% unemployment rate for the overall U.S. labor force last March, as well as the rate of 2.0% for all professional workers. All in all, unemployment among ACS members has not been below this year's level during the past decade and a half except during a three-year period from 1979 to 1981.

Also down last year is the percentage of chemists working on postdoctoral or other fellowships. This year just under 2% of chemists held such positions; a year earlier nearly 3% did so. The level of postdoc employment has not been lower any time in the past 10 years.

Salaries, meanwhile, have risen modestly for chemists from a year ago. The median annual salary for Ph.D. chemists responding to the ACS survey is up 5% to \$44,000. (The

median is the salary that is exceeded by 50% of all respondents.) That's the same increase as reported by Ph.D.s in last year's survey but slightly lower than the rate of growth over the past decade. The 4% increase reported by chemists whose highest degree is a B.S. and the 6% gain for chemists with an M.S. are a bit higher than the increases those chemists reported in 1984. For B.S. chemists, however, the rise in median salary this year is also less than the annual rate of increase for the past 10 years.

As has been true throughout the 1980s, moreover, increases in median salaries have been largely offset by the rising cost of living. After adjustment for changes in consumer prices, in fact, the median salary for all Ph.D. chemists is just 6% higher than it was in 1980, and that for M.S. chemists is up a mere 5%. For chem-

Unemployment this year is highest for chemists who are women or lack a graduate degree

Employment status ^a	Chemists									Chemical engineers	All members ^c
	Total	By sex		By highest degree			By minority status				
		Men	Women	B.S.	M.S.	Ph.D.	Minority ^b	Nonminority			
Employed full time	94.4%	95.5%	88.6%	95.2%	95.6%	93.6%	91.5%	94.7%	94.9%	94.3%	
Employed part time	1.5	1.0	4.1	1.4	1.9	1.4	1.2	1.5	1.8	1.5	
Postdoctoral or fellowship	1.9	1.8	2.6	0.1	0.0	3.3	4.8	1.8	0.1	1.7	
Unemployed											
Seeking employment	1.4	1.2	2.4	2.0	1.6	1.1	2.1	1.3	2.1	1.6	
Not seeking employment	0.7	0.5	2.4	1.3	0.9	0.5	0.3	0.8	1.1	0.8	

^a As of March 1, 1985. ^b Black, Hispanic, American Indian, Alaskan native, Asian, Pacific Islander, or other. ^c Includes ACS members whose highest degree and present work are in neither chemistry nor chemical engineering. Source: ACS survey

Growth in salaries in the past year is a bit less than was typical during the past decade

\$ Thousands	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change		
												1984-85	1980-85	1975-85
CHEMISTS' MEDIAN SALARIES ^a														
B.S.	\$32.0	\$30.9	\$30.0	\$28.5	\$27.5	\$25.0	\$23.5	\$22.0	\$21.0	\$19.8	\$19.0	4%	5%	5%
M.S.	36.0	34.0	33.0	31.6	30.0	26.0	25.0	24.0	22.0	20.5	19.8	6	7	6
Ph.D	44.0	42.0	40.0	37.5	35.0	31.2	29.0	27.4	26.0	24.7	23.0	5	7	7
All chemists	40.0	38.0	36.0	34.7	32.0	28.9	na	na	na	na	na	5	7	na

^a As of March 1. na = not available. Source: ACS survey

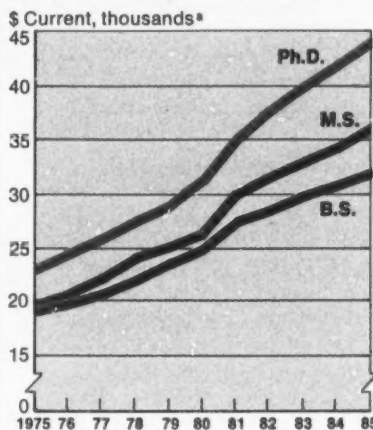
ists with no more than a B.S. degree, moreover, this year's median is 4% less than it was five years ago.

The median provides a simple but also quite rough indication of how any individual chemist is doing with regard to annual income, of course. The chemist earning at the median is a hypothetical person who is locked year by year into the same general level of age and experience. His or her career does not progress as a result of added experience, increased responsibilities, more subordinates, or changing jobs, as does the career of a blood-and-breath chemist.

Experience is a key factor affecting salaries. This is especially the case during the first 20 to 30 years after undergraduate training. Thus the median salary for chemists whose highest degree is a B.S. and who earned that degree 20 to 24 years ago is 85% higher than that for chemists who obtained their degree in the past 12 months. However, the median for B.S. chemists who graduated 40 or more years ago is just 15% above that for B.S. chemists who are 20 to 24 years out of undergraduate school.

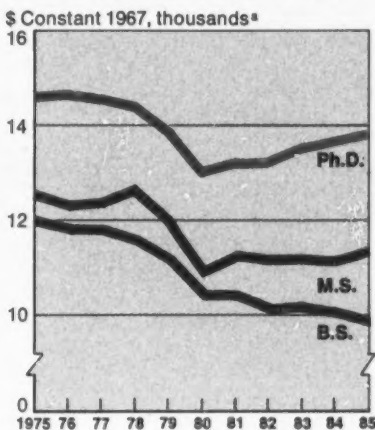
Increases in salaries with experience somewhat mitigate the impact of rising living costs. Thus a chemist who graduated with a B.S. in 1979 and went to work in industry has a median salary this year that is about

Although chemists' salaries have been rising steadily...



* Median salary of chemists as of March 1 each year. Source: ACS survey

... they have barely kept up with inflation since 1980



60% higher than the median had been for this chemist in 1980. Even after adjusting for inflation, the increase in median salary is 20%. For older B.S. chemists—those who obtained their B.S. degree 25 or more years ago—however, this year's median salaries are only about 5% higher than the medians had been for them in 1980 after taking into account increases in the cost of living.

This year's survey of the economic status of chemists, undertaken by the

ACS Office of Statistical Services, differs from the surveys of previous years in that questionnaires were sent to all ACS members in the U.S. who are under 70 years of age and neither retired nor students. In the past, a random sample of such members was surveyed. The results of the 1985 survey are based on nearly 45,000 responses, therefore, rather than the 10,000 to 15,000 responses in other recent surveys. Because of the larger number of responses, more-detailed data are available for a

Salaries tend to reach a plateau 30 years after graduation from undergraduate school

Years since B.S. degree	Annual salaries of nonacademic chemists (\$ thousands) ^a											Overall
	0 to 1	2 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 or more		
B.S.												
90%	\$28.6	\$29.9	\$36.0	\$41.8	\$49.7	\$54.0	\$60.0	\$63.7	\$60.0	\$67.2	\$50.1	
75%	25.0	26.4	32.0	37.2	42.0	46.0	50.0	51.7	52.0	56.0	41.0	
50%	21.6	23.1	27.7	33.0	37.0	40.0	42.4	44.5	43.0	46.0	33.0	
25%	15.6	20.0	24.0	29.0	32.0	33.2	37.0	38.0	36.9	37.5	25.4	
10%	14.3	17.5	21.0	23.9	27.0	26.3	29.6	32.6	30.2	28.0	21.0	
M.S.												
90%	—	34.7	39.6	45.0	52.8	60.0	65.0	68.7	70.0	67.7	57.0	
75%	—	30.0	33.8	39.3	45.0	48.7	53.2	57.0	54.1	57.0	47.0	
50%	—	27.6	30.0	34.8	38.0	43.0	44.8	47.0	47.5	47.0	38.0	
25%	—	24.1	27.0	30.0	32.0	38.0	38.2	39.8	38.4	38.0	30.7	
10%	—	21.5	24.0	25.8	27.4	30.6	32.0	32.9	30.0	27.8	26.0	
Ph.D.												
90%	—	—	43.0	52.0	62.0	67.2	71.5	80.0	81.4	79.6	69.2	
75%	—	—	40.0	47.5	54.0	60.0	62.3	69.0	70.0	68.0	58.3	
50%	—	—	38.0	42.0	48.0	53.0	55.0	59.5	58.0	58.0	49.0	
25%	—	—	35.5	38.5	42.0	45.1	48.0	50.0	49.0	48.0	40.0	
10%	—	—	33.2	34.9	36.0	39.0	39.8	40.0	40.0	39.0	36.0	

* As of March 1, 1985. How to read this table: Using, as an example, nonacademic B.S. chemists two to four years after receiving their B.S. degree, 90% of these chemists have annual salaries of \$29,900 or less, 75% have annual salaries of \$26,400 or less, 50% have annual salaries of \$23,100 or less, 25% have annual salaries of \$20,000 or less, and 10% have annual salaries of \$17,500 or less, as of March 1, 1985. Source: ACS survey

Salaries are appreciably higher for professors teaching at Ph.D.-granting schools

Years since B.S. degree	Median salary (\$ thousands) ^a								Overall
	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 or more	
Ph.D. CHEMISTS EMPLOYED IN ACADEMIA									
Professors with 11- or 12-month basic contract at Ph.D.-granting schools									
Professor	—	—	\$48.0	\$52.0	\$52.0	\$55.0	\$55.0	\$60.0	\$54.2
Associate professor	—	\$35.5	39.5	40.0	38.0	42.8	(43.6)	(44.6)	40.0
Assistant professor	\$28.0	31.0	32.2	(33.1)	—	—	—	—	31.0
Professors with 9- or 10-month basic contract at Ph.D.-granting schools^b									
Professor	—	—	53.2	49.9	51.3	54.1	55.4	61.1	53.4
Associate professor	—	36.7	39.1	39.1	39.1	39.0	40.9	(39.2)	39.1
Assistant professor	30.9	31.8	31.8	(29.9)	(33.9)	—	—	—	31.8
Professors with 11- or 12-month basic contract at non-Ph.D.-granting schools									
Professor	—	—	(39.0)	42.6	44.0	43.3	44.0	49.0	43.0
Associate professor	—	—	25.0	34.4	(32.5)	(35.0)	—	—	31.0
Assistant professor	(22.5)	25.0	(23.0)	(22.0)	—	—	—	—	23.0
Professors with 9- or 10-month basic contract at non-Ph.D.-granting schools^b									
Professor	—	—	36.2	40.0	42.8	42.8	45.1	46.4	42.6
Associate professor	—	30.5	31.8	32.9	36.7	36.4	36.7	(41.7)	33.0
Assistant professor	26.6	26.8	28.8	28.1	(29.3)	(33.1)	—	—	26.9

^a As of March 1, 1985. ^b Salaries of professors working on a 9- or 10-month basic contract have been adjusted to put them on an annualized basis. Note: Where no salary data are shown, sample is too small to provide a meaningful figure; data in parentheses are from relatively small samples, as well, and should be treated with caution. Source: ACS survey

broader array of chemists. This is especially true with the salary data for industrial chemists reported in the table on page 33 and the salary data for academic chemists in the table above.

In general, though, the results from this year's survey are similar to those of previous years. Chemists working in private industry tend to earn more than those employed elsewhere, with the greatest difference being between industrial chemists and academic chemists.

Managers in general earn more than chemists involved with research and development or in production assignments; marketing positions fall between. In industry, too, polymer chemists and agricultural chemists are more likely to be on the top of the salary ladder; analytical chemists and biochemists tend to be at the bottom. In addition, chemists working for

petroleum firms get paid more on the average than their colleagues in other types of companies.

Because of the large number of responses, this year's survey provides information on some groups of chemists who are too few to have been characterized previously. One example is the elite group with the highest salaries. About 1.5% of non-academic chemists report salaries of more than \$100,000 a year. (Only a handful of academic chemists earn that much.) As would be expected, this is an experienced group; more than 80% finished their undergraduate training more than 25 years ago. They are most likely to have a Ph.D.; two thirds do, compared with slightly less than 50% of all non-academic chemists. It is not surprising, either, that more than 80% are managers, with almost half of these being managers of R&D. In addition, it is a

predominately male group; only 2% of the nonacademic chemists with salaries exceeding \$100,000 are women, although 15% of all nonacademic chemists are women.

In general, of course, salaries tend to be lower for women than men. In part, this is because women are less likely to be among the more experienced chemists whose income is higher. Less than a third of women chemists working in industry, for example, earned their B.S. degree 15 or more years ago, but nearly two thirds of the men did so. But even when the data are adjusted to compensate for differences in experience, men's salaries on the average are 10 to 20% higher than those of women, depending on their employer. The difference is greatest among older chemists, moreover. Median salaries for men and women working in industry are very similar for those who

Women's salaries overall are below those of men, wherever they work

Mean salary, \$ thousands ^a	B.S.				M.S.				Ph.D.			
	All chemists	Men	Women	Women as % of men	All chemists	Men	Women	Women as % of men	All chemists	Men	Women	Women as % of men
EMPLOYER												
Private industry	\$35.7	\$36.4	\$31.8	87%	\$40.8	\$41.5	\$37.0	89%	\$51.8	\$52.1	\$46.2	89%
Academic	—	—	—	—	30.0	30.9	26.1	84	39.6	40.5	32.3	80
Government	35.7	36.2	32.7	90	40.9	41.5	36.5	88	50.5	50.8	43.6	86
Other	31.9	32.7	28.8	88	35.9	37.0	31.8	86	45.8	46.3	41.4	90

^a As of March 1, 1985; to facilitate comparison, salaries are adjusted for differences in the average experience for each group. Source: ACS survey

Top salaries go to managers and those working in polymer or agricultural chemistry

Years since B.S. degree		Median salary (\$ thousands) ^a										Overall	
		0 to 1	2 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 or more		
CHEMISTS EMPLOYED FULL TIME IN INDUSTRY													
Sex													
Men	B.S.	\$22.2	\$24.0	\$28.8	\$34.0	\$38.6	\$41.1	\$44.0	\$44.6	\$45.0	\$48.0	\$36.0	
	M.S.	—	26.4	30.5	35.0	40.0	44.8	47.4	50.0	49.6	51.0	40.0	
	Ph.D.	—	—	38.0	42.2	49.6	55.0	58.0	60.0	60.0	60.0	50.0	
Women	B.S.	22.0	23.5	27.3	30.0	33.0	36.0	36.0	38.0	37.9	41.0	27.0	
	M.S.	—	26.5	29.9	33.7	36.0	38.7	41.5	(45.6)	43.0	—	32.4	
	Ph.D.	—	—	37.2	40.0	45.0	48.2	46.2	(50.0)	(60.0)	—	40.0	
Work function													
General management	B.S.	—	(27.5)	33.0	40.0	41.5	45.0	48.0	50.5	51.2	47.0	43.6	
	M.S.	—	—	(33.0)	41.2	45.0	53.5	58.0	54.5	50.0	(50.0)	50.0	
	Ph.D.	—	—	—	(48.2)	54.5	57.5	66.5	66.4	65.0	68.5	61.0	
R&D management	B.S.	—	(24.8)	34.0	39.2	42.5	49.0	51.5	50.0	54.0	58.0	46.3	
	M.S.	—	—	36.6	40.5	45.0	50.0	54.0	55.2	55.3	(57.0)	50.0	
	Ph.D.	—	—	42.0	49.1	55.0	60.0	62.8	70.0	70.0	65.0	60.0	
Basic research	B.S.	22.1	24.0	27.5	31.8	35.8	41.0	(38.0)	37.0	(43.5)	—	27.0	
	M.S.	—	26.0	28.5	32.8	39.0	36.2	(44.6)	45.0	(50.9)	—	33.0	
	Ph.D.	—	—	38.0	42.0	47.0	54.0	56.5	60.0	60.0	56.2	44.0	
Applied research ^b	B.S.	23.0	24.0	28.0	32.0	36.0	37.6	42.0	43.0	42.0	45.0	31.5	
	M.S.	—	27.0	30.0	34.0	38.5	41.2	42.5	45.0	44.9	43.5	36.0	
	Ph.D.	—	—	37.7	41.0	46.0	50.4	53.0	55.0	55.2	55.0	45.0	
Production ^c	B.S.	20.0	23.0	27.0	32.0	36.0	39.5	40.0	39.3	40.0	(32.5)	30.0	
	M.S.	—	(24.3)	30.0	35.0	37.0	39.5	45.0	45.0	42.2	—	36.0	
	Ph.D.	—	—	35.8	42.0	44.3	48.0	56.5	52.0	(58.0)	—	45.0	
Marketing ^d	B.S.	(25.0)	24.0	31.0	37.8	41.3	42.0	46.0	45.0	45.0	53.5	40.0	
	M.S.	—	—	33.5	39.0	39.0	47.5	46.0	(55.0)	50.0	—	41.2	
	Ph.D.	—	—	—	44.5	50.0	53.0	52.0	60.0	(62.5)	(58.0)	52.8	
Work specialty													
Analytical chemistry	B.S.	21.3	23.6	27.8	33.0	36.0	40.0	41.3	42.0	45.0	43.0	31.9	
	M.S.	—	25.8	29.5	34.1	38.0	43.6	45.0	46.5	46.4	(44.5)	36.0	
	Ph.D.	—	—	37.4	43.0	49.0	50.0	54.0	57.8	57.5	(52.5)	45.5	
Agricultural chemistry ^e	B.S.	—	(27.9)	31.0	32.7	38.2	(40.0)	(44.5)	50.0	47.5	—	37.0	
	M.S.	—	—	30.0	33.6	42.2	(49.5)	(52.8)	(46.0)	(48.2)	—	42.0	
	Ph.D.	—	—	—	(42.0)	51.0	54.0	58.0	60.6	(56.5)	(52.6)	53.0	
Biochemistry	B.S.	(20.9)	22.0	25.9	(30.7)	(30.0)	(31.8)	—	—	—	—	28.0	
	M.S.	—	—	27.5	32.0	(34.6)	(39.0)	(42.0)	—	—	—	34.0	
	Ph.D.	—	—	36.7	42.0	46.0	54.0	58.0	63.8	60.0	(58.0)	46.7	
Inorganic chemistry	B.S.	—	(25.9)	30.0	34.0	(33.0)	(38.2)	44.7	(42.0)	48.5	(43.5)	35.7	
	M.S.	—	—	30.6	(36.5)	(37.5)	—	(43.0)	—	(59.5)	—	39.2	
	Ph.D.	—	—	39.0	42.0	46.0	54.5	55.0	51.8	60.5	(65.0)	46.0	
Medicinal chemistry ^f	B.S.	(22.8)	23.5	27.0	30.8	40.0	40.0	43.5	45.0	40.0	(52.2)	30.8	
	M.S.	—	(26.6)	30.0	34.1	40.5	41.5	(43.4)	(44.3)	(48.0)	—	36.0	
	Ph.D.	—	—	37.5	42.5	47.5	57.0	58.5	61.1	55.0	(60.0)	48.0	
Organic chemistry	B.S.	22.5	24.0	28.0	34.0	36.7	41.0	47.3	45.0	42.0	52.5	34.0	
	M.S.	—	25.2	28.8	33.8	37.5	41.6	49.7	46.5	50.0	51.0	38.0	
	Ph.D.	—	—	37.8	41.2	48.0	55.0	56.0	60.0	59.0	58.6	48.0	
Physical chemistry	B.S.	(19.9)	23.0	27.0	31.8	40.0	(39.8)	(46.5)	42.0	48.5	(42.5)	33.3	
	M.S.	—	(27.0)	30.2	35.0	38.8	(44.5)	(48.0)	(48.0)	46.0	—	39.0	
	Ph.D.	—	—	37.6	40.0	51.0	54.8	61.5	64.7	60.0	(60.7)	49.0	
Polymer chemistry	B.S.	23.0	24.0	30.2	37.0	43.2	43.0	46.0	48.0	46.0	50.0	37.4	
	M.S.	—	28.0	32.0	38.7	42.0	44.3	45.3	50.1	50.0	49.5	42.0	
	Ph.D.	—	—	38.0	42.0	50.2	55.2	58.2	60.0	59.5	62.0	51.0	
Theoretical chemistry	B.S.	—	(22.6)	28.5	(33.0)	(37.0)	(41.0)	—	—	(37.9)	—	33.0	
	M.S.	—	—	(28.0)	34.6	38.5	(42.1)	(43.0)	—	(55.0)	—	37.6	
	Ph.D.	—	—	38.0	42.9	50.0	60.0	60.0	64.0	66.0	62.0	51.9	

a As of March 1, 1985. b Includes development. c Includes quality control. d Includes purchasing, technical service, and economic evaluation. e Includes food chemistry. f Includes pharmaceutical chemistry. Note: Where no salary data are shown, sample is too small to provide a meaningful figure; data in parentheses are from relatively small samples, as well, and should be treated with caution. Source: ACS survey

Joblessness falls to the lowest level since 1981 for chemists; postdocs also decline

Employment status ^a	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Employed full time	95.2%	93.7%	93.5%	94.9%	95.6%	95.9%	95.0%	95.7%	95.4%	94.7%	95.0%
Employed part time	1.5	1.7	1.7	1.4	1.1	1.0	2.0	1.0	1.1	1.3	1.3
Postdoctoral or fellowship	1.9	2.9	2.6	2.2	2.2	2.2	1.9	1.9	2.1	2.2	2.0
Unemployed	1.4	1.7	2.2	1.5	1.1	0.9	1.1	1.4	1.5	1.9	1.6

^a As of March 1; excludes unemployed chemists not seeking employment. Source: ACS survey

Unemployment evenly low across various jobs

	% of chemists in category	% unemployed ^a
MOST RECENT EMPLOYER		
Industry	45%	1.5%
Academic	27	1.3
Government	13	1.4
Other	15	1.2
MOST RECENT WORK FUNCTION		
R&D ^b	35%	1.1%
Teaching	27	1.3
R&D management	12	1.2
Production ^c	8	2.1
General management	5	1.6
Marketing ^d	4	1.7
Other	9	1.9
MOST RECENT WORK SPECIALTY		
Analytical	22%	1.5%
Organic	15	1.0
Polymer	13	1.2
Biochemistry	8	1.8
Agricultural ^e	7	1.6
Inorganic	6	1.3
Theoretical	4	2.4
Physical	4	1.7
Medicinal ^f	4	1.5
Other chemistry	14	1.3
Nonchemistry	4	1.0

^a As of March 1, 1985; excludes unemployed chemists not seeking employment. ^b Nonacademic only. ^c Includes quality control. ^d Includes purchasing, technical service, and economic evaluation. ^e Includes food chemistry. ^f Includes pharmaceutical chemistry. Source: ACS survey

received their undergraduate degree less than 10 years ago, for example. But for chemists who are 25 to 29 years out of undergraduate school, the divergency in median salaries ranges from a 14% advantage for men with an M.S. degree to a 25% advantage for men with a Ph.D. compared to women with the same degrees.

Not unexpectedly, therefore, women seem less satisfied than men with their salaries, as well as with their chances for promotion. The ACS survey indicates that 25% of the women consider that they are not

Pay is highest for chemists working in the oil industry

Industry	% of industrial chemists				Mean salary (\$ thousands) ^a		
	All chemists	B.S.	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Chemical	33%	27%	28%	40%	\$36.0	\$43.2	\$52.1
Pharmaceutical ^b	16	15	18	16	34.4	38.9	51.6
Coatings	6	8	7	4	35.2	35.9	47.6
Petroleum	6	4	6	7	40.5	46.0	58.7
Food	4	5	5	3	33.4	41.7	43.8
Metals and minerals	3	3	3	2	32.0	33.3	51.1
Rubber	2	3	2	2	37.0	34.0	48.2
Other manufacturing	23	24	23	22	35.7	41.3	46.6
Nonmanufacturing	7	10	8	5	33.5	39.2	48.8

^a As of March 1, 1985; to facilitate comparison, mean salaries are adjusted for differences in the average experience for each group. ^b Includes personal care products. Source: ACS survey

paid fairly, compared with fellow employees; 20% of the men think their salaries are unfair. As for promotions, 27% of the women but just 19% of the men believe that their chances for professional advancement as scientists are poorer than those of fellow employees who are similarly qualified. And 33% of the women, compared to 22% of the men, judge their chances for managerial advancement are less than those of like qualified colleagues. These perceptions of unequal treatment by employers are slightly lower than those found in a similar survey of ACS members five years ago.

Women also are more likely to be unemployed, as has been true in previous years as well. The unemployment rate for women chemists is 2.4%, double that for men, and down only slightly from last year's 2.6%. Women, too, are more likely than men to be working part-time or at postdoctoral fellowships.

This year's ACS survey also provides a comparison between the marital status of men and women working full-time as chemists. As of last March, 43% of the women but only 15% of the men were single; 31% of the women, compared to 11% of the men, had never been married. This difference to a large degree

probably stems from the women as a group being younger; nearly 40% of women chemists, compared with about 15% of men chemists, received their B.S. degree less than 10 years ago. Of the women who are married, 58% are married to scientists, including 32% to chemists. Among married men, only 22% are married to scientists and 10% to chemists.

One unexpected finding of this year's survey is the apparent endangered species status of environmental chemists. Respondents were asked to indicate the one scientific specialty most related to their work. In recent years, about 6% considered themselves environmental chemists. This year, however, less than 1% did so, and more than two thirds of those few are academic chemists.

Later this month, the ACS Office of Statistical Services will publish a detailed compilation of results from its 1985 survey of the economic status of ACS members. This report, "Salaries 1985," can be purchased from Distribution, Room 210, American Chemical Society, 1155-16th St., N.W., Washington, D.C. 20036. The office also will be publishing later this year a special study dealing with women chemists, as well as reports on minority chemists and members of selected ACS local sections. □

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JULY 15, 1985

CHEMICAL & ENGINEERING

NEWS



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NSF's Erich Bloch

An industrialist pushes agency in new directions

Page 6

News of the Week

■ Aldicarb poisoning of watermelons raises questions of pesticide applications. **Page 3**

■ New York state files lawsuit to prevent sale of homes in Love Canal area. **Page 4**

■ The Administration plans to reduce the stockpile of strategic materials. **Page 4**

■ NRC panel suggests that Oak Ridge National Laboratory find better locations for disposal of its nuclear wastes. **Page 5**

■ Protocol signed by 21 countries pledges 30% reduction in emissions or transboundary movement of sulfur dioxide by 1993 from levels found in 1980. **Page 5**

■ Eastman Kodak will get into fiber optics, making connectors and connector installation kits. **Page 5**

Cover: Photo courtesy of NSF

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Business

MTBE is riding high as lead phasedown in gasoline boosts demand for octane enhancers, but the boom probably won't last. **Page 12**

Size of chemical workforce has decreased as has percentage of production workers from automation, recession in 1980s. **Page 13**

International Business

Finland's Kemira rises from a maker of fertilizer constituents to an international firm by acquiring U.S., Dutch companies. **Page 14**

Innovation means not being afraid to fail and ready to accept ideas from outside sources, U.K. conference concludes. **Page 16**

Government

Superfund, drinking water, and air quality standards top Congress' agenda as budget battle holds up funding bills. **Page 18**

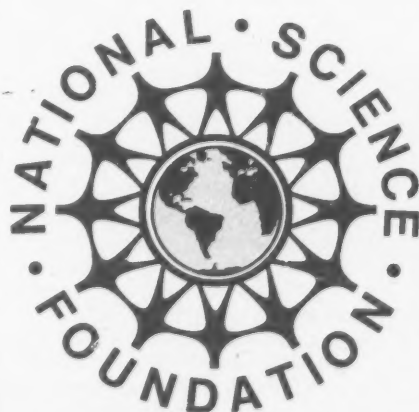
New EPA maps charting areas susceptible to acid rain become tools of environmental groups' efforts to trigger legislation. **Page 20**

Science

Different stereospecific routes to making geometric isomers of silyl enol ethers mapped by Howard, Wisconsin chemists. **Page 22**

Technology

Model for the structure of skin, by-product of research on a new softener, may allow design of drug delivery systems. **Page 24**



News Focus

Focus of Erich Bloch, director of the National Science Foundation, is clearly on the world of science and technology and how to make it better.

Page 6

ure of government to protect consumers. A spokesman for one pesticides producer asks, "How can it be the government's fault if growers choose to apply a pesticide illegally?" Officials believe that growers may have used aldicarb on the watermelons because, unlike approved insecticides which have to be applied repeatedly, one application of the pesticide is enough for the growing season.

Under its screening system, California officials are checking 20 sample watermelons from each of the state's 3500 patches—a process that will take about a week to complete. Berryhill says that growers whose melons pass the latest tests will be asked to declare that they have not used an aldicarb pesticide within the past 12 months. Violators will be subject to \$100,000 fines for perjury. □

Suit filed to block sale of Love Canal homes

New York's attorney general has filed suit against the Love Canal Area Revitalization Agency and its chairman to block the sale or lease of six of the 450 homes in Ring 3, the so-called Emergency Declaration Area around the Love Canal hazardous waste dump in Niagara Falls.

Attorney general Robert Abrams said it was "folly to move people back to the Love Canal" when serious questions remain about the health risks to people "living in the vicinity of toxic chemical contamination." Folly or not, in May the revitalization agency decided that no harm would result from the rehabilitation and reoccupancy of the six homes. It based this decision on a limited review called an environmental assessment.

The suit argues that the environmental assessment is "legally inadequate" and calls for a more detailed environmental impact statement. Among other things, the state

claims the assessment failed to consider the potential health hazards to people who move close to the abandoned waste site, and to provide information that would determine whether chemicals from the waste site have migrated or may migrate to the homes. The suit, filed in New York Superior Court, Niagara County, also claims that the agency never considered open space as an alternative land use for Ring 3.

Revitalization agency chairman Michael C. O'Laughlin, who is also mayor of Niagara Falls, says the state's suit is premature. He claims his agency, which was formed in 1980 to purchase the 450 homes in Ring 3, is many steps removed from trying to lease or sell the six homes.

Love Canal was used by Hooker Chemical & Plastics Corp., now Occidental Chemical, to dispose of some 21,000 tons of toxic chemicals from 1942 to 1953. A federal lawsuit against the firm is still pending. □

Reagan plan trims strategic materials stockpile

President Reagan has proposed new goals for the national defense stockpile of strategic materials. Following a two-year study of the stockpile, the President concluded that the goals set during the Carter Administration were too high. He is effectively lowering the dollar value of the stockpile from \$16.3 billion to just \$6.7 billion.

The strategic stockpile, originated in the 1950s, is a reserve of nonfuel materials that the U.S. might require in a war, but that might not be available in sufficient quantities from domestic or reliable foreign

sources. The Administration has three objectives for the material in the stockpile. It should be sufficient to meet military, industrial, and essential civilian needs for a three-year conventional conflict; be consistent with Defense Department estimates; and reflect current industrial and defense mobilization requirements.

Reagan began re-evaluating the stockpile in April 1982, with the start of a major program to improve the reserve policy. A study from that effort, completed late last year, is the basis for the change in mate-

New goals set for reserve strategic stockpile

Commodity	Quantities
Aluminum oxide	208,139 tons abrasive grain equivalents
Bauxite	4,278,912 tons AP ^a
Bauxite, refractory	274,926 long calcined tons
Beryllium	437 tons Be ^a
Chromite, refractory	180,000 dry tons
Chromium	594,123,000 tons Cr ^a
Cobalt	6 million lb
Copper	29,048 tons
Diamonds, industrial	7,950,000 karats
Graphite, Ceylon	415 tons
Iodine	5.5 million lb
Lead	300,000 tons
Manganese	889,667 tons Mn ^a
Mica, Muscovite block	200,000 lb
Nickel, electrolytic	5000 tons
Niobium	2,532,419 lb Nb ^a
Quartz, crystal	1.8 million lb
Rubber	127,455 metric tons
Silver	87,500,000 troy oz
Tantalum	1,023,320 lb Ta ^a
Tin	150,000 metric tons
Titanium	21,100 tons
Tungsten	52,215,245 lb W ^a
Vanadium	722 tons V metal
Zinc	85,000 tons

^a Metal equivalents. Source: White House Office of the Press Secretary

rials proposed now. Any changes in the stockpile must be approved by Congress. The present review covers 42 of the 62 materials in the reserves. The remaining materials are stockpiled in much smaller quantities and will be reviewed later.

Surplus material now in the reserve will be sold gradually over a five-year period. Funds collected from these sales, estimated to be about \$2.5 billion, will be used to buy new materials, or to reduce the federal deficit. Some of the substances proposed to be dropped from the stockpile include bismuth, cadmium, fluorspar, platinum, and silicon carbide. It is also expected that as much as 50 million troy oz of silver will be sold.

The strategic reserve is a fairly sensitive topic, as many Congressmen represent districts that store or process these materials. Some amendments to pending legislation already have been made that would maintain the stockpile at the high levels set by the Carter Administration. □

"If you're a refiner who's had red ink for the past year, can you convince your banker to invest in an MTBE unit that might have a payback in two to three years or that, because of imports, might not have a payback for several years?" asks L. Michael Grupa, a senior consultant at Pace Consultants, Houston.

Grupa believes the opportunity to get into the MTBE business is limited. Although the banning of lead additives to gasoline will re-

sult in a surge in octane requirements, the gradual decline of gasoline consumption in the U.S. means that surge will reach a plateau. About the same time, he points out, imports of gasoline could begin to have a substantial impact.

"There might be a window of a few years of high demand for MTBE," Grupa says. "If you didn't start planning an octane enhancer unit in January, you may already be out of the game." □

Employment patterns changing in chemicals

The chemical workforce is slowly, but steadily, changing. The recession, the drive for efficiency, and the increased use of automated systems have all worked to reduce the size of the workforce and to lower the percentage of production workers within the chemical workforce. In spite of the recovery in the chemical industry, employment is still well below prerecession levels.

According to data from the Department of Labor, U.S. chemical employment reached its peak, like so many things in the chemical industry, in 1979. At that time, the government figures show, an average of 1,109,300 employees worked in the U.S. chemical industry. Some up and down movement occurred in 1980 and 1981, but 1982 and 1983

showed definite declines. By 1983, the chemical workforce had fallen to 1,046,800, almost 6% below its level just four years earlier and the lowest that it had been since 1976.

In 1984, the number of total employees in the chemicals and allied products category rose once again, increasing 1.4% to 1,061,000, but in the first quarter of this year, the average fell back once again to 1,060,400. This is essentially the same level of employment 11 years ago.

Hourly production workers in the chemicals and allied products industry have fared even worse in the past few years, according to the government figures. The total number of production workers peaked at 633,300 in 1979, but by 1983 it

had fallen more than 8% to 580,700. Production employment rose 1.4% in 1984 to 589,000, but in the first quarter of this year it declined almost 1% to 584,800.

These figures also show the steady erosion of production workers as a percentage of total employment in the chemical industry. In 1976, almost 58% of chemical employees were classified as hourly production workers, up barely from 57% the year before as the 1975 recession ended for chemicals. By the end of the decade, that percentage had slipped back to 57%, but since then has declined steadily to between 55 and 56% for the past three years. In the first quarter of this year, reflecting the apparent slowdown in the chemical industry, the percentage dropped to 55%.

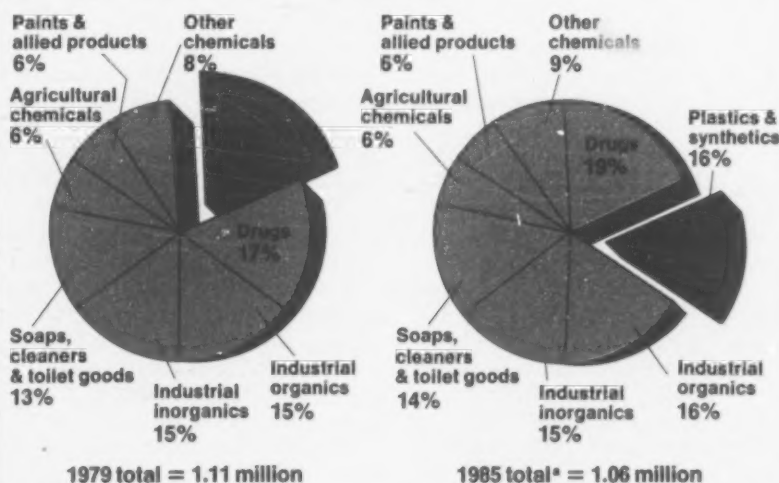
The percentages of workers in the various chemical industry sectors also have changed over the years. In 1979, 19% of all chemical industry employees were in the plastics and synthetics sector, which also includes fibers. By the first quarter of this year, that percentage had fallen to 16%. Paints and allied products as well as agricultural chemicals in this year's first quarter each employed slightly less than 6% of all chemical workers, down from a bit more than 6% in 1979.

Employment has increased or remained stable in industrial inorganics and organics, drugs, soaps, and miscellaneous chemicals. The drug industry has replaced plastics as the biggest employer of people working in the chemical industry with an almost 19% share, up from a little more than 17% in 1979. In the first quarter of 1985, industrial organics employed almost 16% of the chemical workforce, up from about 15% in 1979, and the soaps, cleaners, and toilet goods sector's employment increased to 14% from less than 13%.

Thus, it looks as if, as the 1980s progress and chemical companies move more deeply into higher-value-added products, the shift will continue away from the hourly production worker and, in terms of share of employment, toward the more specialty-oriented product categories.

William Storck, New York

Number of plastics and synthetic workers has fallen as per cent of total in past five years



* First-quarter average. Note: Figures do not total 100% because of rounding. Source: Labor Department

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News of the Week

■ **Indian scientists claim cyanide poisoning caused some deaths in Bhopal disaster; U.S. counterparts deny it.** Page 6

■ **First products made in space by U.S.—polystyrene beads that are uniformly 10 μ m in diameter—are being marketed by NBS.** Page 7

■ **Many scientists oppose the Administration's Strategic Defense Initiative, claiming it will speed up the arms race.** Page 7

■ **OTA memorandum urges renewal of joint U.S./U.S.S.R. space research.** Page 8

■ **Monsanto will acquire G. D. Searle for \$2.7 billion.** Page 8

Cover: A. H. Robins research chemist synthesizes new compound showing promise as nonsedative antihistamine

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Business

Bio-Response, California-based firm specializing in contract cell culture, believes its continuous mass culturing system can play a key role in moving products from laboratory to market. Page 10

Government

Supreme Court upholds portion of the pesticide law that calls for binding arbitration in data compensation disputes. Page 21

EPA does a poor job of protecting farm workers from pesticide exposure, environmental think tank reports. Page 22

Education

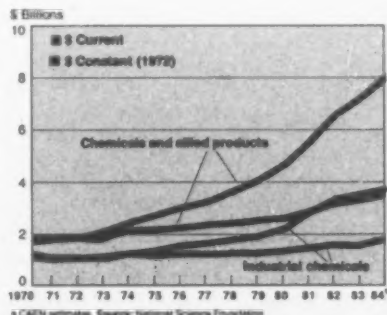
The computer age will have a profound effect on engineers of the future and the engineering curriculum must change to meet the challenges, Purdue conferees urge. Page 24

Technology

Catalytic reforming of methane provides a method of recovering high-temperature heat to raise the chemical energy of fuel. Page 26

Special Report

Total spending for R&D in the U.S. is expected to rise 11% this year, topping \$100 billion for the first time. For chemical firms, outlays also will be up 11% to more than \$8 billion. Page 28



Facts & Figures for Chemical R&D

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Where R&D funds come from and who does the work. How funds are divided among basic and applied research and development

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R&D spending by government agencies. How federal support is divided among specific areas and types of R&D

3 **Industry** 43

How industry apportions its R&D outlays. Spending by individual chemical companies. Manpower in industrial R&D

4 **Universities and colleges** 53

Sources and uses of academic R&D funds. Largest spenders on R&D. Demographic trends

This year, for the first time, total spending for research and development in the U.S. will top \$100 billion. One of the chief reasons for the 11% growth expected in R&D spending is the substantial rise in support from the Department of Defense. In addition, the nation's healthier economy has encouraged spending. As the National Science Foundation puts it, "The 1981-82 recession and the recovery that followed solidified the belief [of many industrial executives] that, to maintain their companies' sales, profitability, and market share, it was imperative to strengthen their R&D programs."

An NSF survey finds that a third of R&D officials say their companies have boosted their R&D spending partly because of the 1981 Economic Recovery Tax Act. This act gives companies a 25% annual tax credit for increases in their R&D spending made between July 1, 1981, and Dec. 31, 1985.

The U.S. this year is expected to spend \$13.3 billion for basic research, \$22.9 billion for applied research, and \$70.4 billion for development—increases of 10%, 8%, and 12%, respectively.

The 10% advance in spending for basic research compares to increases of 11% in 1984, 10% in 1983, and only 8% in 1982. Double-digit increases for basic research in the past three years are heartening to those in the scientific community who have been urging that greater stress be placed on this area, which provides essential underpinnings for industrial growth.

The Reagan Administration's growing push for im-

Squibb Corp. photo

proved national defense is reflected in the recent rises in Department of Defense (DOD) support of R&D. In fiscal year 1985, the department's funding of R&D is expected to climb 24% to \$34.1 billion. The department's support rose 11% in fiscal 1983 and 20% in 1984.

In fiscal 1985, DOD will account for 65% of all federal support of R&D. The other leading government funders

of R&D are the Department of Energy (9% of the total) and the Department of Health & Human Services (9%).

In 1985, industry is expected to spend \$77.5 billion in performing R&D, a gain of 12% over 1984. Of the 1985 industrial total, \$52.4 billion (68%) will come from industry's own coffers and \$25.1 billion (32%) from the government.

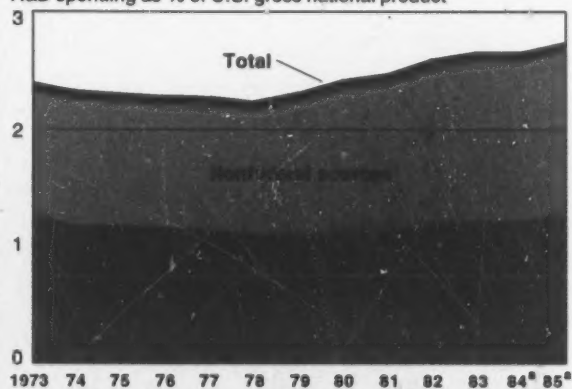
Of the \$69.3 billion spent in 1984 on industrial R&D, an estimated \$8.1 billion (12% of the total) was accounted for by the chemicals and allied products industry. R&D spending by chemical companies is being spurred not only by the nation's economic recovery but by scientific progress in such areas as biotechnology.

University R&D funds rose 12% to \$9.6 billion in 1985. This growth was made possible by increases of 12% in funding from the government, 14% from industry, 11% from academic sources, and 11% from other nonprofit institutions. Many firms are showing a greater desire to support R&D (especially basic research) on university campuses. However, two thirds of all funding for academic R&D still comes from the government.

R&D spending in the U.S. is expected to rise slightly to 2.7% of the gross national product in 1985, from 2.6% in 1982, 1983, and 1984. The recent U.S. figures are essentially the same as those of West Germany, but are greater than those of other industrialized western nations. However, when defense spending is excluded, R&D spending in the U.S. is just 1.8% of GNP, compared with 2.5% for West Germany and 2.3% for Japan. □

R&D's share of GNP continues to climb from low in 1978

R&D spending as % of U.S. gross national product



* Estimated. Source: National Science Foundation

Healthy growth for R&D outlays

As inflation moderates, real spending for R&D is rising at a 7%-a-year rate, the best gain in more than 20 years

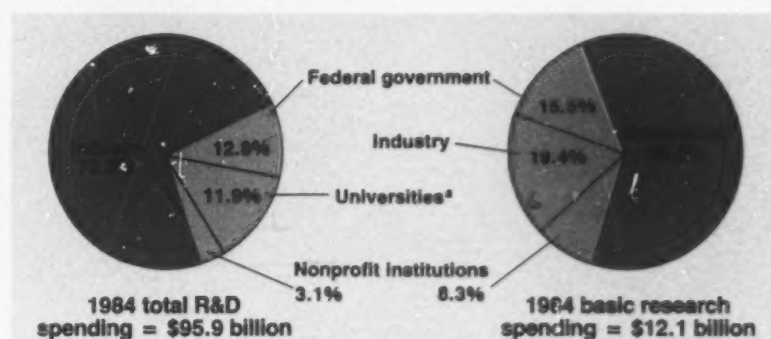
Spending for research and development in the U.S. will total \$106.6 billion this year, according to National Science Foundation estimates. Thus, for the second year in a row, if the current estimate is borne out, outlays will climb 11%.

Those are strong gains—somewhat better than 1983's 9% and 1982's 10%, certainly—but not spectacular. During the past decade, R&D spending has increased at an annual rate of nearly 12%, and during the four years before 1982 it rose at an annual rate of close to 14%.

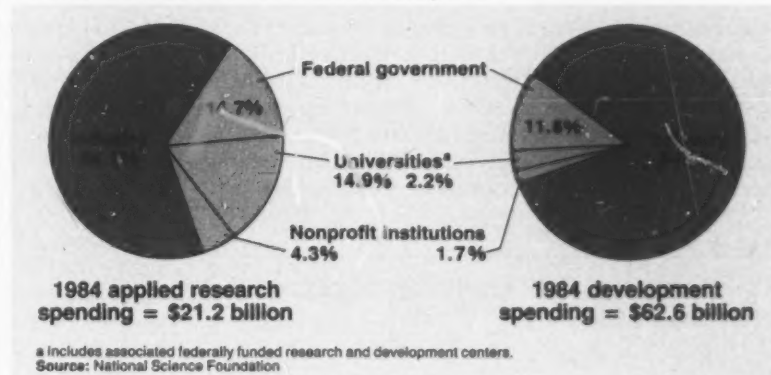
After adjustment for inflation, on the other hand, the rise in R&D outlays this year looks much more favorable. As the impact of inflation has moderated during the past two years, spending has been rising at a 7%-a-year clip, compared to growth of between 4 and 5% during the preceding half-dozen years. (Measured in constant dollars, R&D outlays actually fell in 1974 and 1975, as well as in the three-year period 1969-71.) The 7% gain for this and last year is the greatest real growth since 1964.

This year, the two major sources of R&D funds—the federal government and private industry, which together account for all but about 3% of the total—both are expected to boost financial support 11%. □

Industrial labs dominate total R&D spending, even though they handle less than a fifth of basic research . . .



. . . because they perform two thirds of applied research and all but about 15% of development



TRENDS IN R&D: Declining percentage of government-supported R&D is civilian related

% of total outlays	1985*	1984*	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968	1967	1966
Federal	47%	47%	47%	46%	46%	47%	49%	50%	50%	51%	51%	51%	53%	56%	56%	57%	58%	61%	62%	64%
Defense related	30	29	27	25	23	22	23	24	25	26	26	27	30	32	32	33	34	35	35	33
Space related	6	6	6	7	7	7	7	7	8	8	8	8	8	9	9	10	11	13	14	19
Civilian related	11	12	14	14	16	18	19	19	17	17	17	16	15	15	15	14	13	13	13	12
Nonfederal	53	53	53	54	54	53	51	50	50	49	49	49	47	44	44	43	42	39	38	36

* Estimated. Source: National Science Foundation

SOURCES OF R&D FUNDS: Industry has been biggest R&D supporter since 1980 . . .

\$ Billions, current	1985 ^a	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change	
												1984-85	1975-85
Federal government	\$49.8	\$44.7	\$40.3	\$36.5	\$33.4	\$29.5	\$26.8	\$23.9	\$21.6	\$19.9	\$18.1	11%	11%
Industry	53.2	48.0	43.2	40.1	35.9	30.9	26.1	22.5	19.6	17.7	15.8	11	13
Universities and colleges	2.3	2.1	1.8	1.7	1.5	1.3	1.2	1.0	0.9	0.8	0.7	11	13
Other nonprofit institutions	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.6	0.5	10	10
TOTAL	\$106.6	\$95.9	\$86.6	\$79.3	\$71.8	\$62.6	\$54.9	\$48.1	\$42.8	\$39.0	\$35.2	11%	12%

^a Estimated. Source: National Science Foundation

. . . but growth is uniform through all sectors this year after adjustment for inflation

\$ Billions, constant (1972)	1985 ^a	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change	
												1984-85	1975-85
Federal government	\$21.4	\$19.9	\$18.6	\$17.5	\$17.1	\$16.5	\$16.4	\$15.9	\$15.4	\$15.1	\$14.5	7%	4%
Industry	22.9	21.5	20.1	19.3	18.4	17.3	16.0	14.9	14.0	13.4	12.6	7	6
Universities and colleges	1.0	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6	7	5
Other nonprofit institutions	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	6	4
TOTAL	\$45.9	\$42.8	\$40.1	\$38.2	\$36.7	\$35.1	\$33.6	\$32.0	\$30.5	\$29.5	\$28.2	7%	5%

^a Estimated. Source: National Science Foundation

PERFORMERS OF R&D: Almost three quarters of all R&D is done by industry, . . .

\$ Billions, current	1985 ^a	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change	
												1984-85	1975-85
Industry	\$77.5	\$69.3	\$62.8	\$58.0	\$51.8	\$44.5	\$38.2	\$33.3	\$29.8	\$27.0	\$24.2	12%	12%
Federal government	13.3	12.3	10.6	9.1	8.4	7.6	7.4	6.8	6.0	5.8	5.4	8	9
Universities and colleges	9.6	8.6	7.7	7.3	6.8	6.1	5.4	4.6	4.1	3.7	3.4	12	11
Associated FFRDCs ^b	3.0	2.8	2.7	2.5	2.5	2.2	1.9	1.7	1.4	1.1	1.0	7	12
Other nonprofit institutions	3.2	3.0	2.7	2.4	2.3	2.2	2.0	1.7	1.5	1.4	1.3	8	9
TOTAL	\$106.6	\$95.9	\$86.6	\$79.3	\$71.8	\$62.6	\$54.9	\$48.1	\$42.8	\$39.0	\$35.2	11%	12%

^a Estimated. ^b Federally funded research and development centers administered by universities and colleges. Source: National Science Foundation

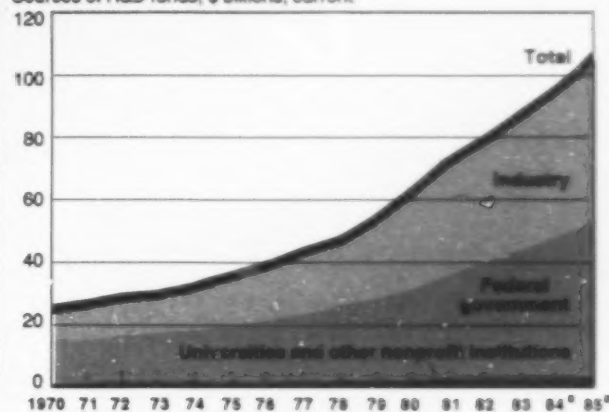
. . . which is boosting its spending, in constant dollars, 8% this year

\$ Billions, constant (1972)	1985 ^a	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change	
												1984-85	1975-85
Industry	\$33.4	\$31.0	\$29.2	\$28.0	\$26.5	\$24.9	\$23.4	\$22.1	\$21.3	\$20.4	\$19.2	8%	6%
Federal government	5.7	5.4	4.9	4.4	4.3	4.3	4.5	4.5	4.3	4.4	4.3	4	3
Universities and colleges	4.1	3.8	3.6	3.5	3.5	3.4	3.3	3.1	2.9	2.8	2.8	8	4
Associated FFRDCs ^b	1.3	1.2	1.3	1.2	1.3	1.3	1.2	1.1	1.0	0.9	0.8	4	5
Other nonprofit institutions	1.4	1.3	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.0	1.0	4	3
TOTAL	\$45.9	\$42.8	\$40.1	\$38.2	\$36.7	\$35.1	\$33.6	\$32.0	\$30.5	\$29.5	\$28.2	7%	5%

^a Estimated. ^b Federally funded research and development centers administered by universities and colleges. Source: National Science Foundation

R&D spending will top \$100 billion for first time in 1985 . . .

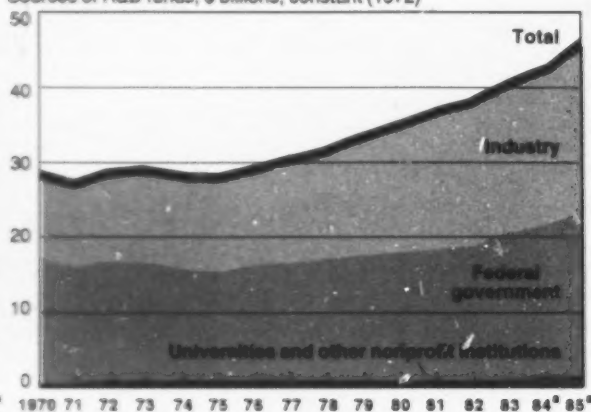
Sources of R&D funds, \$ billions, current



Estimated. Source: National Science Foundation

. . . as its growth rate continues to outstrip inflation

Sources of R&D funds, \$ billions, constant (1972)



CHARACTER OF R&D: Development is benefiting the most from increased R&D outlays . . .

\$ Billions, current	1985 ^a	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change	
												1984-85	1975-85
Basic research	\$13.9	\$12.1	\$10.9	\$ 9.9	\$ 9.2	\$ 8.1	\$ 7.3	\$ 6.4	\$ 5.5	\$ 5.0	\$ 4.6	10%	11%
Applied research	22.9	21.2	20.2	18.5	16.9	14.1	12.4	10.8	9.7	9.0	7.9	8	11
Development	70.4	62.6	55.4	50.9	45.8	40.5	35.3	30.9	27.5	25.0	22.7	12	12

^a Estimated. Source: National Science Foundation

. . . with this year's gain, in real dollars, well above its past growth rate

\$ Billions, constant (1972)	1985 ^a	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change	
												1984-85	1975-85
Basic research	\$ 5.7	\$ 5.4	\$ 5.0	\$ 4.8	\$ 4.7	\$ 4.5	\$ 4.4	\$ 4.3	\$ 3.9	\$ 3.8	\$ 3.7	6%	4%
Applied research	9.9	9.5	9.4	8.9	8.6	7.9	7.6	7.2	6.9	6.8	6.3	4	5
Development	30.3	28.0	25.7	24.5	23.4	22.7	21.6	20.5	19.6	18.9	18.1	8	5

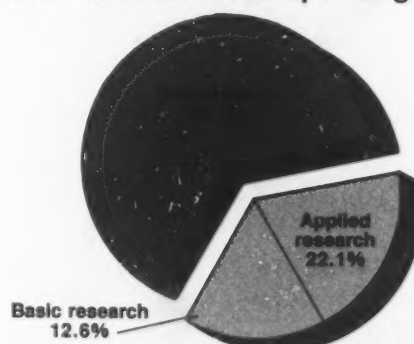
^a Estimated. Source: National Science Foundation

EMPLOYED SCIENTISTS AND ENGINEERS: Two thirds of physical scientists are chemists

	Thousands employed	Per cent
Scientists	1525.9	44.0%
Physical scientists	235.9	6.8
Chemists	158.9	4.6
Physicists/astronomers	48.4	1.4
Other physical scientists	28.6	0.8
Other scientists	1290.0	37.2
Engineers	1940.0	56.0
Chemical engineers	114.9	3.3
Other engineers	1825.1	52.7
TOTAL	3465.9	100.0%

Note: 1983 data. Source: National Science Foundation

Development accounts for almost two thirds of total R&D spending



1984 total R&D spending = \$95.9 billion

Source: National Science Foundation

ABSTRACTS OF PAPERS IN *CHEMICAL ABSTRACTS*: Biochemistry's share hits new high

% IN EACH GROUP	1984	1983	1982	1981	1980	1979	1978	1977	1976
Biochemistry	40.5%	38.3%	39.5%	39.0%	39.8%	38.8%	38.3%	37.9%	36.8%
Physical, inorganic, and analytical chemistry	28.8	29.6	28.5	28.0	28.6	28.9	27.4	27.9	27.5
Applied chemistry and chemical engineering	17.6	19.4	19.5	19.1	18.9	19.4	20.8	19.7	18.8
Organic chemistry	7.6	7.3	7.2	8.7	7.4	7.6	8.0	8.8	8.7
Macromolecular chemistry	5.5	5.4	5.3	5.2	5.3	5.3	5.5	5.7	6.2
% OF ALL BIOCHEMISTRY ABSTRACTS									
Mammalian hormones ^a	12.4%	12.9%	12.2%	6.8%	6.0%	5.9%	5.9%	5.5%	5.9%
Pharmacology	11.6	11.8	12.0	12.4	12.0	11.9	12.3	12.0	12.0
Mammalian biochemistry ^a	11.3	11.1	11.6	15.6	16.3	17.1	17.2	17.7	16.3
Toxicology	8.0	8.5	8.1	8.7	6.3	7.4	7.5	6.2	6.4
Plant biochemistry ^a	6.2	5.9	6.2	5.8	5.7	5.8	5.4	5.8	6.1
Enzymes	5.8	6.1	5.9	5.9	6.2	6.4	5.7	6.1	6.4
General biochemistry	5.3	5.8	6.0	7.5	6.6	7.0	6.5	7.0	7.1
Microbial biochemistry ^a	5.2	5.1	5.3	5.6	5.2	5.3	5.1	5.3	5.0
Others	34.2	32.8	32.7	31.7	33.7	33.2	34.4	34.4	34.8
% OF ALL PHYSICAL, INORGANIC, AND ANALYTICAL CHEMISTRY ABSTRACTS									
Nuclear chemistry	22.2%	22.5%	22.6%	21.6%	23.2%	25.1%	20.7%	21.1%	19.7%
Spectra	18.0	17.6	17.2	18.0	18.2	17.0	17.0	18.1	17.8
Electric phenomena	10.8	10.0	10.5	11.0	11.2	11.4	10.9	10.5	10.5
Crystallography and liquid crystals	7.8	8.3	8.7	8.9	8.1	8.2	9.2	8.9	9.7
General physical chemistry	6.9	7.3	7.3	7.2	7.1	6.6	6.6	6.8	7.0
Analytical chemistry	6.3	6.2	5.4	5.8	5.6	5.6	7.2	5.8	6.6
Others	28.0	28.1	28.3	27.5	26.6	25.8	28.4	28.8	28.7
% OF ALL APPLIED CHEMISTRY AND CHEMICAL ENGINEERING ABSTRACTS									
Water, wastes, and pollution	21.0%	19.6%	21.7%	24.0%	22.5%	20.8%	20.8%	23.2%	18.6%
Metals and alloys	18.9	19.1	22.2	17.9	22.0	23.6	24.0	24.2	27.8
Mineralogical and geological chemistry	14.6	14.1	13.6	14.1	15.7	15.8	16.8	13.4	17.6
Fossil fuels, derivatives, and related products	10.1	10.3	9.4	9.4	8.9	7.8	8.2	9.2	6.0
Unit operations and processes	7.0	7.5	6.9	6.4	6.0	6.1	6.4	5.8	4.8
Others	28.4	29.4	26.2	28.2	24.9	25.9	23.8	24.2	25.2
% OF ALL ORGANIC CHEMISTRY ABSTRACTS									
Physical organic chemistry	32.0%	30.5%	31.5%	37.0%	38.8%	38.8%	36.8%	41.3%	38.4%
Organometallic and organometalloidal compounds ^a	17.1	16.3	14.8	8.3	8.2	8.5	8.9	8.5	8.7
Heterocyclic compounds ^a	15.6	16.2	15.6	18.2	17.3	16.0	17.5	17.0	17.4
Aromatic compounds ^a	6.3	7.1	7.2	8.7	7.8	8.2	8.6	8.5	8.0
Carbohydrates	5.7	5.8	5.8	5.4	5.7	6.0	5.2	4.6	5.1
Amino acids, peptides, and proteins ^a	4.8	4.5	4.4	4.2	3.7	4.1	4.0	3.7	4.3
Biomolecules and their synthetic analogs ^b	4.4	4.5	3.7	—	—	—	—	—	—
Aliphatic compounds ^a	3.6	4.3	5.2	6.6	6.0	6.0	6.9	5.9	6.5
Others	10.5	10.8	11.8	11.6	12.5	12.4	12.1	10.5	11.6
% OF ALL MACROMOLECULAR CHEMISTRY ABSTRACTS									
Synthetic high polymers	34.0%	34.4%	34.7%	30.3%	27.0%	26.3%	25.6%	26.5%	28.3%
Plastics manufacture and uses	24.2	24.4	21.9	26.4	28.1	27.8	28.1	27.5	26.8
Cellulose, lignin, paper, and other wood products	9.6	9.1	9.7	10.1	10.9	11.1	10.6	10.0	9.1
Coatings, inks, and related products	7.8	6.6	7.6	7.5	7.4	8.1	7.5	7.5	7.6
Textiles	7.3	7.9	8.9	9.9	10.1	10.1	12.1	11.0	11.1
Synthetic elastomers and natural rubber	7.3	7.5	7.8	7.9	8.4	7.6	8.0	8.5	8.8
Others	9.8	10.1	9.4	7.9	8.1	9.0	8.1	9.0	8.5

^a Definition of section content changed in 1982. ^b New section in 1982. Source: Chemical Abstracts Service

U.S. PATENTS: Total increases, as does percentage granted to foreign residents

	1984	1983	1982	1981	1980	1979 ^a	1978	1977	1976	1975	1974
U.S.^b	38,364	32,872	33,896	37,356	37,152	30,605	40,979	41,383	44,162	46,603	50,643
Foreign^c	28,837	23,990	23,993	24,463	24,675	18,248	25,123	23,886	26,074	25,291	25,632
TOTAL	67,201	56,862	57,889	61,819	61,827	48,853	66,102	65,269	70,236	71,994	76,275
% Foreign	42.9%	42.2%	41.4%	39.6%	39.9%	37.4%	38.0%	36.6%	37.1%	35.3%	33.6%

^a Patent figures were low in 1979 because the U.S. Patent & Trademark Office was short of funds to print patents it might otherwise have issued. ^b U.S. patents granted to U.S. residents.

^c U.S. patents granted to residents of foreign countries. Source: U.S. Patent & Trademark Office

Most of the growth focuses on defense

FEDERAL OBLIGATIONS FOR R&D: Spending for defense has doubled since 1981

Department or agency	Total R&D (\$ millions)				
	1985 ^a	1984 ^a	1983	1982	1981
Agriculture	\$ 898.9	\$ 871.8	\$ 847.6	\$ 797.3	\$ 774.0
Agricultural Research Service	466.9	452.9	443.4	404.9	394.1
Cooperative State Research Service	256.8	237.7	232.3	219.0	199.4
Commerce	270.6	360.0	335.0	336.3	328.0
National Bureau of Standards	91.2	96.0	95.0	88.8	82.5
National Oceanic & Atmospheric Administration	165.2	244.3	222.0	222.0	201.4
Defense	34,142.1	27,540.0	22,992.8	20,622.6	16,508.6
Air Force	14,700.7	12,756.4	10,812.6	9,357.9	6,969.2
Army	5,153.8	4,475.5	3,998.1	3,760.5	3,244.2
Navy	9,715.4	7,526.0	6,068.2	5,845.1	5,006.0
Defense agencies ^b	4,513.4	2,729.5	2,052.3	1,618.1	1,248.2
Energy	4,962.3	4,825.6	4,536.7	4,708.2	4,918.2
Environmental Protection Agency	280.9	250.0	240.7	335.1	235.7
Health & Human Services	4,954.0	4,864.3	4,352.5	3,940.7	3,927.1
National Institutes of Health	4,345.4	4,240.2	3,789.2	3,433.1	3,333.2
Interior	369.0	421.8	382.5	381.1	427.1
National Aeronautics & Space Administration	3,339.4	2,888.9	2,661.6	3,077.9	5,406.6
National Science Foundation	1,414.0	1,238.5	1,062.0	975.3	961.6
Tennessee Valley Authority	80.7	73.3	63.0	85.0	68.9
Others	1,541.7	1,501.5	1,237.1	1,173.1	1,271.6
TOTAL	\$52,253.6	\$44,835.8	\$38,711.5	\$36,432.6	\$34,917.4

^a Estimated. ^b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. Note: Fiscal years. Source: National Science Foundation

FEDERAL OBLIGATIONS FOR RESEARCH: Bigger gains for basic than for applied research

Department or agency, \$ millions	1985 ^a		1984 ^a		1983		1982		1981	
	Basic research	Applied research	Basic research	Applied research	Basic research	Applied research	Basic research	Applied research	Basic research	Applied research
Agriculture	\$ 419.7	\$ 450.0	\$ 386.4	\$ 455.6	\$ 362.0	\$ 455.5	\$ 330.8	\$ 435.7	\$ 314.1	\$ 426.9
Agricultural Research Service	240.1	201.2	232.5	194.9	215.3	192.9	186.2	186.4	186.4	181.5
Cooperative State Research Service	128.6	128.2	100.8	136.8	98.8	133.5	91.3	127.7	83.9	115.5
Commerce	18.4	201.2	20.5	272.6	19.2	265.6	16.9	259.2	16.2	233.2
National Bureau of Standards	17.8	63.7	19.2	63.1	18.4	63.1	16.5	57.4	15.6	50.6
National Oceanic & Atmospheric Administration	0	127.2	0	194.6	0	188.9	0	188.5	0	168.5
Defense	913.2	2406.2	816.6	2168.2	785.6	2437.0	686.7	2266.1	604.3	1996.6
Air Force	206.2	577.2	187.9	514.1	164.2	524.2	145.8	488.1	125.8	491.5
Army	238.5	564.1	209.2	464.2	208.3	485.3	187.7	451.6	148.1	388.4
Navy	359.9	492.3	308.5	426.1	305.4	521.6	280.3	498.4	238.0	460.0
Defense agencies ^b	108.6	772.6	111.0	763.8	107.7	905.9	72.9	828.1	92.4	656.7
Energy	944.5	1269.0	841.7	1231.7	767.7	1193.4	642.2	1,053.9	586.3	827.3
Environmental Protection Agency	25.5	174.1	22.7	155.2	22.2	152.4	32.7	210.7	10.5	207.8
Health & Human Services	2925.9	1679.1	2793.1	1705.9	2475.4	1545.4	2144.7	1460.9	1900.4	1591.9
National Institutes of Health	2738.1	1264.9	2607.7	1286.3	2313.0	1165.2	2020.7	1103.8	1766.8	1181.5
Interior	102.8	248.6	124.7	276.3	103.0	254.7	76.5	275.0	80.7	289.2
National Aeronautics & Space Administration	826.7	1086.1	689.1	1012.0	617.0	927.8	535.7	871.4	531.1	876.0
National Science Foundation	1335.8	78.2	1172.5	66.0	999.1	62.9	916.1	57.1	896.6	58.9
Tennessee Valley Authority	5.6	8.4	5.0	8.0	5.6	6.7	4.6	8.1	4.8	9.4
Others	119.5	793.7	108.7	775.8	103.3	692.0	94.7	642.5	96.3	654.3
TOTAL	\$7637.6	\$8396.6	\$6981.0	\$8127.3	\$6260.1	\$7993.4	\$5461.6	\$7540.6	\$5041.3	\$7171.5

^a Estimated. ^b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. Note: Fiscal years. Source: National Science Foundation

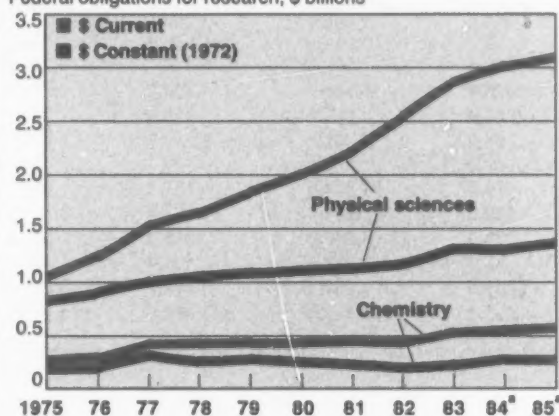
FEDERAL OBLIGATIONS FOR SCIENTIFIC DISCIPLINES: No growth for chemical funding

\$ Millions for research only	1985 ^a	1984 ^a	1983	1982	1981	Annual change	
						1984-83	1981-1985
Engineering	\$ 3,845.5	\$ 3,551.8	\$ 3,517.0	\$ 3,386.5	\$ 3,071.5	8%	6%
Chemical	143.5	143.8	145.0	95.1	147.6	0	-1
Metallurgy and materials	369.2	346.3	332.5	309.1	256.0	7	10
Environmental sciences	1,336.2	1,279.3	1,251.2	1,148.3	1,121.1	4	5
Life sciences	5,981.4	5,749.1	5,177.9	4,745.5	4,435.6	4	8
Mathematics and computer sciences	579.2	446.2	419.4	350.1	278.9	30	20
Physical sciences	3,143.1	3,002.5	2,891.4	2,500.4	2,220.5	5	9
Chemistry	595.7	571.1	520.3	481.2	436.9	4	5
Physics	1,932.9	1,868.9	1,854.6	1,610.5	1,345.6	3	9
Other sciences	1,148.8	1,079.4	996.6	891.4	1,085.2	6	1
TOTAL	\$16,034.2	\$15,106.3	\$14,253.5	\$13,022.2	\$12,212.8	6%	6%

^a Estimated. Note: Fiscal years. Source: National Science Foundation

Federal funding for physical sciences changed little after adjusting for inflation

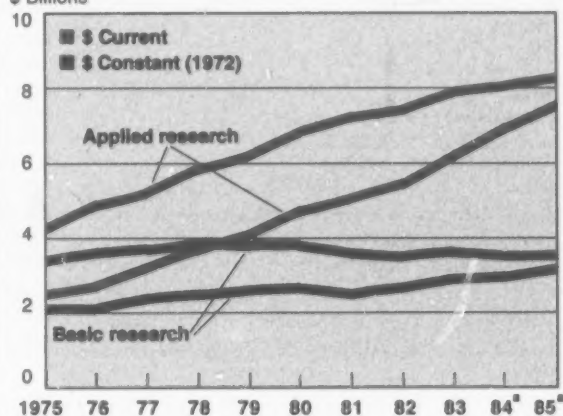
Federal obligations for research, \$ billions



^a Estimated. Note: Fiscal years. Source: National Science Foundation

Basic research is winning a bigger share of total government research funds

\$ Billions



^a Estimated. Note: Fiscal years. Source: National Science Foundation

FEDERAL OBLIGATIONS FOR DEVELOPMENT: Defense gets 85% of total funds

Department or agency	Development (\$ millions)				
	1985 ^a	1984 ^a	1983	1982	1981
Agriculture	\$ 29.2	\$ 29.9	\$ 30.0	\$ 30.6	\$ 33.0
Agricultural Research Service	25.6	25.5	25.5	25.8	26.2
Cooperative State Research Service	0	0	0	0	0
Commerce	51.0	66.9	50.2	60.2	78.6
National Bureau of Standards	9.6	13.7	13.6	14.9	16.3
National Oceanic & Atmospheric Administration	38.0	49.8	33.1	33.5	32.9
Defense	30,822.7	24,555.3	19,770.1	17,669.8	13,907.7
Air Force	13,917.3	12,054.4	10,124.2	8,724.0	6,351.9
Army	4,351.2	3,802.1	3,304.5	3,121.3	2,707.7
Navy	8,863.2	6,791.4	5,241.2	5,066.4	4,308.0
Defense agencies ^b	3,632.2	1,854.7	1,038.7	717.1	499.1
Energy	2,748.8	2,752.2	2,575.6	3,012.1	3,504.6
Environmental Protection Agency	81.3	72.1	66.1	91.7	107.4
Health & Human Services	348.9	365.3	331.7	335.2	434.9
National Institutes of Health	342.4	346.1	311.0	308.7	384.9
Interior	17.7	20.6	24.8	29.6	57.3
National Aeronautics & Space Administration	1,424.6	1,187.7	1,116.8	1,670.7	3,999.4
National Science Foundation	0	0	0	2.2	6.1
Tennessee Valley Authority	66.7	60.3	50.7	72.3	54.7
Others	628.5	617.0	442.0	435.8	520.9
TOTAL	\$36,219.4	\$29,727.5	\$24,458.0	\$23,410.4	\$22,704.6

^a Estimated. ^b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. Note: Fiscal years. Source: National Science Foundation

BASIC RESEARCH: Energy Department cuts funding for chemistry

Department or agency	Federal obligations (\$ millions)									
	1985 ^a		1984 ^a		1983		1982		1981	
	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	\$ 43.8	\$ 41.9	\$ 42.9	\$ 41.0	\$ 40.0	\$ 38.2	\$ 36.2	\$ 34.5	\$ 33.7	\$ 31.8
Agricultural Research Service	37.3	36.0	36.1	34.8	33.5	32.2	30.0	28.9	27.7	26.5
Cooperative State Research Service	3.9	3.9	4.2	4.2	4.1	4.1	3.8	3.8	3.4	3.4
Commerce	15.1	4.8	16.3	5.2	15.7	4.7	13.7	4.2	12.6	2.9
National Bureau of Standards	14.9	4.6	15.9	4.8	15.7	4.6	13.7	4.2	12.6	2.9
Defense	228.1	65.3	205.3	57.8	198.4	55.6	188.7	51.5	194.9	43.5
Air Force	50.3	21.2	45.9	19.9	39.3	17.5	34.2	13.9	32.3	12.9
Army	65.5	20.9	57.6	18.2	58.7	19.4	59.6	20.0	49.5	14.5
Navy	110.2	23.3	99.0	19.8	98.0	18.7	93.1	17.7	79.7	15.9
Defense agencies ^b	2.0	0	2.7	0	2.5	0	1.8	0	33.4	0.2
Energy	789.5	93.7	897.0	113.1	839.2	104.3	530.8	75.5	480.2	70.0
Environmental Protection Agency	2.3	2.0	2.1	1.8	2.3	1.5	3.8	3.5	2.9	2.9
Health & Human Services	73.8	65.9	69.3	61.7	61.8	55.0	53.2	48.0	53.2	46.0
National Institutes of Health	72.0	64.1	68.6	61.1	60.9	54.2	52.9	47.7	52.8	47.6
Interior	3.8	2.8	4.0	3.0	2.9	1.8	8.1	2.5	10.1	6.8
Geological Survey	3.8	2.8	4.0	3.0	2.6	1.8	2.6	1.9	3.0	2.0
National Aeronautics & Space Administration	416.7	18.2	359.4	8.8	329.5	7.7	280.6	5.2	268.9	6.6
National Science Foundation	388.3	118.6	339.7	103.7	283.5	88.5	266.6	83.3	254.8	81.5
Tennessee Valley Authority	4.0	4.0	3.7	3.7	3.5	3.5	3.0	3.0	3.1	3.1
Others	12.8	0.8	11.4	0.8	10.4	1.0	9.1	0.8	10.5	1.1
TOTAL	\$1958.2	\$418.0	\$1751.1	\$400.6	\$1587.2	\$362.2	\$1393.8	\$312.0	\$1324.9	\$298.2

^a Estimated. ^b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. *Note:* Fiscal years. *Source:* National Science Foundation

APPLIED RESEARCH: Defense furnishes more than 40% of federal funds for chemistry

Department or agency	Federal obligations (\$ millions)									
	1985 ^a		1984 ^a		1983		1982		1981	
	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	\$ 27.0	\$ 25.1	\$ 27.0	\$ 25.1	\$ 27.6	\$ 25.6	\$ 26.0	\$ 24.0	\$ 25.0	\$ 22.7
Agricultural Research Service	18.5	17.1	17.9	16.6	18.6	17.2	17.1	15.8	16.2	14.6
Cooperative State Research Service	6.4	6.4	6.8	6.8	6.7	6.7	6.4	6.4	5.8	5.8
Commerce	37.8	10.7	33.7	9.1	33.9	9.3	32.6	8.8	30.5	8.9
National Bureau of Standards	30.4	9.4	25.3	7.3	26.7	8.1	25.4	7.3	24.4	7.5
Defense	382.2	75.7	471.1	74.4	562.0	66.3	500.0	66.6	335.2	47.2
Air Force	60.5	15.1	55.0	14.0	54.5	13.7	50.5	13.3	49.7	14.3
Army	105.9	46.7	71.6	43.9	86.9	39.9	83.2	41.4	58.6	24.6
Navy	71.2	13.7	66.0	16.3	135.2	12.3	128.7	11.7	98.5	8.1
Defense agencies ^b	144.6	0.2	278.5	0.3	285.4	0.3	237.6	0.3	128.4	0.3
Energy	625.0	18.1	615.4	14.2	584.8	13.3	482.8	29.9	390.2	13.7
Environmental Protection Agency	15.8	14.5	13.7	12.6	13.9	12.6	16.6	15.3	66.4	66.4
Health & Human Services	25.3	21.6	24.6	20.9	22.6	19.2	17.6	15.3	25.1	22.1
National Institutes of Health	23.3	19.6	23.7	19.9	21.5	18.1	17.2	14.9	24.8	21.8
Interior	7.1	3.9	7.8	6.5	5.5	4.4	10.2	3.7	7.3	5.3
Geological Survey	4.8	3.8	7.0	6.0	4.7	3.8	4.0	3.2	5.0	4.0
National Aeronautics & Space Administration	46.6	2.0	43.2	1.8	40.4	1.7	8.9	1.0	11.3	1.1
National Science Foundation	12.7	4.9	10.3	4.3	9.4	3.9	6.0	2.6	2.2	0.9
Others	5.4	1.2	4.7	1.7	4.2	1.8	5.8	1.8	2.4	0.4
TOTAL	\$1184.9	\$177.7	\$1251.5	\$170.6	\$1304.3	\$158.1	\$1106.5	\$169.2	\$895.6	\$188.7

^a Estimated. ^b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. *Note:* Fiscal years. *Source:* National Science Foundation

OBLIGATIONS FOR ENGINEERING RESEARCH: Little change for chemical engineering

Department or agency	Federal obligations (\$ millions)									
	1985 ^a	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976
	Engi- neering	Chemical engi- neering	Engi- neering	Chemical engi- neering	Engi- neering	Chemical engi- neering	Engi- neering	Chemical engi- neering	Engi- neering	Chemical engi- neering
Agriculture	\$ 55.0	\$ 6.3	\$ 55.2	\$ 6.3	\$ 54.7	\$ 6.2	\$ 51.2	\$ 5.8	\$ 50.7	\$ 5.3
Agricultural Research Service	34.0	3.4	33.0	3.3	32.9	3.2	30.0	2.9	30.0	2.7
Cooperative State Research Service	7.1	0	7.6	0	7.4	0	6.9	0	6.3	0
Commerce	29.8	1.5	37.3	1.4	37.4	1.3	32.0	2.0	28.5	1.0
National Bureau of Standards	25.4	1.5	30.0	1.4	29.4	1.3	23.8	2.0	19.7	1.0
Defense	1650.9	40.1	1463.4	38.5	1573.9	44.9	1473.3	39.0	1324.1	3.1
Air Force	468.3	3.5	417.7	2.9	419.3	3.1	387.3	2.9	388.3	2.6
Army	357.6	24.1	303.5	21.7	318.9	29.3	297.2	24.4	266.0	18.3
Navy	430.1	12.4	374.8	11.8	395.5	11.9	378.0	11.6	256.4	9.9
Defense agencies ^b	394.8	0.2	367.4	0.2	440.2	0.6	410.8	0.2	313.4	0.2
Energy	479.5	45.8	439.1	54.4	440.2	51.9	420.8	1.1	270.2	30.6
Environmental Protection Agency	41.7	16.3	37.1	16.6	47.8	16.7	76.4	26.0	77.2	55.8
Health & Human Services	45.5	0	44.4	0	39.7	0	41.4	0	48.8	0
National Institutes of Health	45.4	0	44.3	0	39.7	0	41.4	0	43.6	0
Interior	78.1	0.4	119.0	0.7	91.4	0.4	87.1	1.4	68.5	3.4
Geological Survey	4.3	0	6.3	0	5.7	0	8.2	0.2	7.0	0
National Aeronautics & Space Administration	1006.3	1.3	908.6	1.1	799.6	1.0	771.7	0.4	780.7	0.3
National Science Foundation	203.6	31.0	168.6	25.7	142.5	21.5	129.9	18.8	121.0	19.1
Tennessee Valley Authority	4.6	0	4.2	0	3.2	0	5.1	0	7.6	0
Others	250.5	0.8	274.9	1.0	286.6	1.1	297.6	0.6	294.2	1.0
TOTAL	\$3845.5	\$143.5	\$3551.8	\$143.8	\$3517.0	\$145.0	\$3386.5	\$95.1	\$3071.5	\$147.6

^a Estimated. ^b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. Note: Fiscal years. Source: National Science Foundation

UNIVERSITY RESEARCH: Biggest growth is in math and computer sciences

Federal obligations, \$ millions	1985 ^a	1984 ^a	1983	1982	1981	1980	1979	Annual change	
								1984-85	1978-85
Engineering	\$ 510.4	\$ 449.4	\$ 408.7	\$ 361.5	\$ 365.3	\$ 323.7	\$ 269.6	14%	11%
Chemical	32.7	28.4	23.6	19.4	21.9	20.3	19.2	15	9
Metallurgy and materials	115.2	96.7	86.0	75.3	69.5	57.3	52.3	19	14
Environmental sciences	361.1	325.2	316.9	274.7	280.3	297.0	275.5	11	5
Life sciences	2873.8	2757.7	2460.0	2205.0	2117.2	1984.7	1796.0	4	8
Mathematics and computer sciences	232.1	186.8	172.4	139.7	121.4	94.6	87.5	23	18
Physical sciences	748.0	684.5	596.5	559.1	525.2	461.0	402.8	9	11
Chemistry	250.5	233.2	205.7	189.6	193.5	159.5	140.1	7	10
Physics	414.7	379.0	328.8	308.0	274.5	246.1	214.7	9	12
Other sciences	332.5	327.4	297.8	255.7	297.5	302.7	285.6	2	3
TOTAL	\$5057.9	\$4733.0	\$4252.3	\$3795.7	\$3706.9	\$3463.6	\$3117.0	7%	8%

^a Estimated. Note: Fiscal years. Source: National Science Foundation

UNIVERSITY BASIC RESEARCH: Government funding of basic chemistry continues to climb

Federal obligations, \$ millions	1985 ^a	1984 ^a	1983	1982	1981	1980	1979	Annual change	
								1984-85	1978-85
Engineering	\$ 388.6	\$ 333.4	\$ 295.5	\$ 259.0	\$ 237.3	\$ 208.4	\$ 164.0	17%	15%
Chemical	27.2	22.7	18.9	16.8	19.8	16.9	12.5	20	14
Metallurgy and materials	102.8	87.4	76.8	69.6	62.6	51.9	47.6	18	14
Environmental sciences	326.2	300.5	284.3	258.0	241.9	255.3	229.9	9	6
Life sciences	2067.8	1928.9	1701.7	1483.7	1314.6	1219.5	1140.1	7	10
Mathematics and computer sciences	196.8	158.9	146.8	118.8	102.6	79.8	69.0	24	19
Physical sciences	645.3	577.2	502.2	455.3	434.7	375.9	323.3	12	12
Chemistry	224.5	204.2	181.9	165.3	164.7	136.1	114.3	10	12
Physics	347.7	307.7	264.7	238.6	222.4	194.3	166.2	13	13
Other sciences	178.4	166.9	147.2	120.5	148.2	152.4	125.4	7	6
TOTAL	\$3803.1	\$3465.8	\$3077.7	\$2693.3	\$2479.0	\$2291.3	\$2051.7	10%	11%

^a Estimated. Note: Fiscal years. Source: National Science Foundation

Industry hiked spending 10% last year

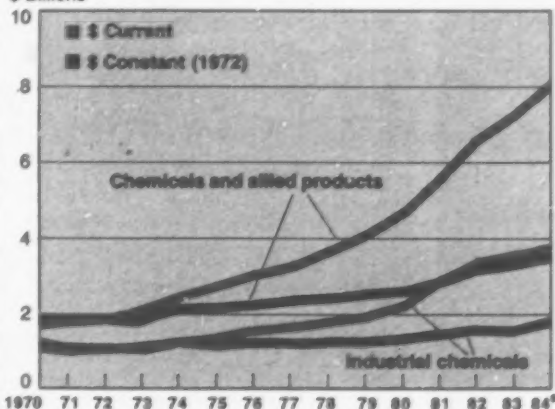
TOTAL FUNDS FOR INDUSTRIAL R&D: Chemical industry's share is nearly 12% of total

\$ Millions	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Chemicals and allied products	\$ 8,070*	\$ 7,287	\$ 6,859	\$ 5,825	\$ 4,836	\$ 4,038	\$ 3,580	\$ 3,202	\$ 3,017	\$ 2,727	\$ 2,450	11%	13%
Industrial chemicals	3,760*	3,409	3,301	2,802	2,197	1,962	1,798	1,668	1,524	1,391	1,299	10	11
Drugs					1,777	1,517	1,308	1,117	1,091	981	807		
Other chemicals	4,310*	3,878	3,358	2,823	662	559	474	417	401	354	344	11	14
Other industries	61,230*	55,529	51,337	46,185	39,669	34,188	29,724	26,823	23,980	21,460	20,437	10	12
TOTAL	\$89,300	\$82,616	\$77,996	\$51,810	\$44,505	\$38,226	\$33,304	\$29,825	\$26,997	\$24,187	\$22,887	10%	12%

* C&EN estimates. Source: National Science Foundation

Chemical industry's R&D outlays move higher despite inflation

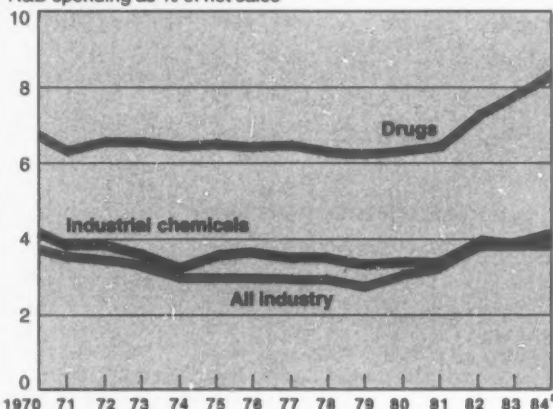
\$ Billions



* C&EN estimates. Source: National Science Foundation

Percentage for drug firms is about double that for all industry

R&D spending as % of net sales



* C&EN estimates. Source: National Science Foundation

COMPANY FUNDS FOR INDUSTRIAL R&D: Industry boosts its own R&D spending

\$ Millions	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Chemicals and allied products	\$ 7,600*	\$ 6,839	\$ 6,226	\$ 5,205	\$ 4,264	\$ 3,692	\$ 3,250	\$ 2,907	\$ 2,751	\$ 2,490	\$ 2,236	11%	13%
Industrial chemicals	3,300*	2,969	2,879	2,393	1,856	1,617	1,473	1,387	1,275	1,173	1,105	11	12
Drugs	3,250*	2,931	2,490	2,064	1,755								
Other chemicals	1,050*	940	856	747	653	2,075	1,777	1,520	1,476	1,317	1,131	11	14
Other industries	39,650*	35,761	33,286	30,223	26,212	22,016	18,865	16,433	14,685	13,092	12,431	11	12
TOTAL	\$47,250	\$42,600	\$39,512	\$35,428	\$30,476	\$25,708	\$22,115	\$19,340	\$17,436	\$15,582	\$14,667	11%	12%

* C&EN estimates. Source: National Science Foundation

FEDERAL FUNDS FOR INDUSTRIAL R&D: Chemical industry's share is slim

\$ Millions	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Chemicals and allied products	\$ 470 ^a	\$ 448	\$ 434	\$ 421	\$ 372	\$ 348	\$ 330	\$ 295	\$ 266	\$ 236	\$ 214	5%	8%
Industrial chemicals	460 ^a	440	423	409	341	345	325	281	249	218	194	5	9
Drugs and other chemicals	10 ^a	8	11	12	31	1	5	14	17	18	20	25	-7
Other industries	21,530 ^a	19,767	18,049	15,961	13,657	12,172	10,859	10,190	9,295	8,369	8,006	9	10
TOTAL	\$22,000	\$20,215	\$18,483	\$16,382	\$14,025	\$12,518	\$11,189	\$10,485	\$9,561	\$8,605	\$8,220	9%	10%

^a C&EN estimates. Source: National Science Foundation

R&D BY U.S. COMPANIES ABROAD: Growing faster for chemical industry than elsewhere

\$ Millions	1984 ^a	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Chemicals and allied products	\$ 800	\$ 733	\$ 684	\$ 715	\$ 603	\$ 500	\$ 395	\$ 332	\$ 312	\$ 269	\$ 208	9%	12%
Industrial and other chemicals	390	346	313	287	245	199	151	133	108	85	82	13	16
Drugs	410	387	371	428	357	301	244	199	204	184	126	6	8
Other industries	2600	2501	2413	2679	2562	2254	1814	1545	1347	1185	1092	4	8
TOTAL	\$3400	\$3234	\$3098	\$3393	\$3165	\$2754	\$2209	\$1877	\$1659	\$1454	\$1300	5%	11%

^a C&EN estimates. Source: National Science Foundation

CHEMICAL R&D SPENDING: Rise planned for 1985 is less than in early 1980s

\$ Millions	1985 ^a	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Air Products	\$ 51	\$ 44	\$ 40	\$ 37	\$ 32	\$ 30	\$ 24	\$ 23	\$ 24	\$ 19	\$ 16
American Cyanamid	250	237	215	190	172	148	130	108	96	83	73
Celanese	105	94	85	100	104	94	92	83	77	70	64
Dow Chemical	530	507	492	460	404	314	269	232	203	188	167
Du Pont^b	1100	1000	875	775	647	591	509	461	367	353	336
Ethyl	42	40	39	39	37	34	29	25	28	25	19
W. R. Grace	90	79	71	62	55	45	42	37	32	28	30
Hercules	79	72	74	74	85	57	50	43	40	37	32
Lubrizol	38	38	37	36	33	28	23	21	19	17	17
Monsanto	450	370	290	264	233	208	161	136	132	114	116
Olin	53	54	51	47	39	31	26	25	25	23	24
PPG Industries	185	150	127	127	119	103	83	70	61	56	50
Rohm & Haas	120	109	100	92	77	67	54	49	45	43	39
Stauffer Chemical^c	68	66	63	57	49	44	35	32	32	28	23
Union Carbide	260	265	245	240	207	166	161	156	156	143	120
TOTAL	\$3441	\$3125	\$2804	\$2600	\$2273	\$1960	\$1688	\$1501	\$1337	\$1227	\$1126
ANNUAL CHANGE	10%	11%	8%	14%	16%	16%	12%	12%	9%	9%	9%

^a Planned. ^b Excludes petroleum and coal segments. ^c All figures are restated for fiscal year ending Sept. 30; Stauffer Chemical was acquired by Chemagro Corp. in first-quarter 1985. Sources: Company data and estimates

BASIC RESEARCH IN INDUSTRY: Industrial chemical firms do most of chemical industry total

\$ Millions	1983	1981	1979	1977	1976	1975	1974	1973
Chemicals and allied products	\$ 650	\$ 569	\$ 366	\$337	\$332	\$298	\$294	\$241
Industrial chemicals	350	380	190	183	168	155	130	110
Drugs	na	185	150	130	128	113	118	100
Other chemicals	na	23	26	25	36	31	46	32
Other industries	1454	1045	792	574	505	432	415	398
TOTAL	\$2104	\$1814	\$1158	\$911	\$837	\$730	\$709	\$637

Note: No data for 1978, 1980, and 1982. na = not available. Sources: National Science Foundation and C&EN estimates based on NSF data

APPLIED RESEARCH IN INDUSTRY: Four times more than basic research for chemical industry

\$ Millions	1983	1981	1979	1977	1976	1975	1974	1973
Chemicals and allied products	\$ 2,638	\$ 2,391	\$1726	\$1347	\$1219	\$1102	\$ 965	\$ 857
Industrial chemicals	1,372	1,250	853	695	593	537	565	489
Drugs	na	890	684	479	470	426	299	273
Other chemicals	na	251	189	173	156	138	101	95
Other industries	10,767	8,321	5499	4289	3964	3477	3292	2946
TOTAL	\$13,405	\$10,712	\$7225	\$5636	\$5183	\$4578	\$4257	\$3803

Note: No data for 1978, 1980, and 1982. na = not available. Sources: National Science Foundation and C&EN estimates based on NSF data

DEVELOPMENT IN INDUSTRY: Accounted for half of R&D spending by chemical firms in 1983

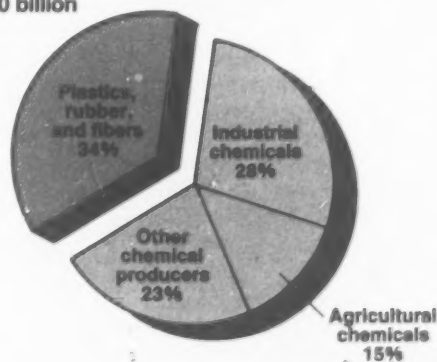
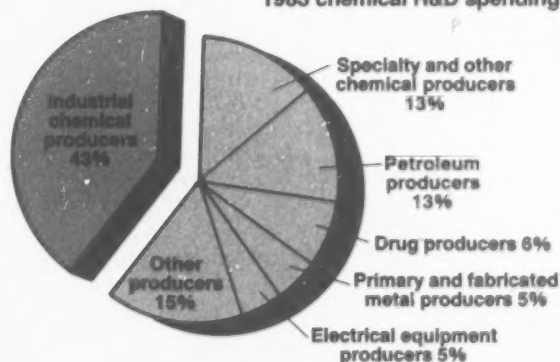
\$ Millions	1983	1981	1979	1977	1976	1975	1974	1973
Chemicals and allied products	\$ 3,999	\$ 2,665	\$ 1,946	\$ 1,518	\$ 1,466	\$ 1,330	\$ 1,191	\$ 1,018
Industrial chemicals	1,687	1,191	920	790	763	700	604	521
Drugs	na	1,000	682	508	493	444	390	325
Other chemicals	na	475	344	219	209	184	197	172
Other industries	43,308	36,819	27,897	21,760	19,511	17,550	16,730	15,790
TOTAL	\$47,307	\$39,484	\$29,843	\$23,278	\$20,977	\$18,879	\$17,921	\$16,808

Note: No data for 1978, 1980, and 1982. na = not available. Sources: National Science Foundation and C&EN estimates based on NSF data

More than 40% of chemical R&D is done by industrial chemical producers . . .

. . . and a third of chemical R&D funds spent on polymers

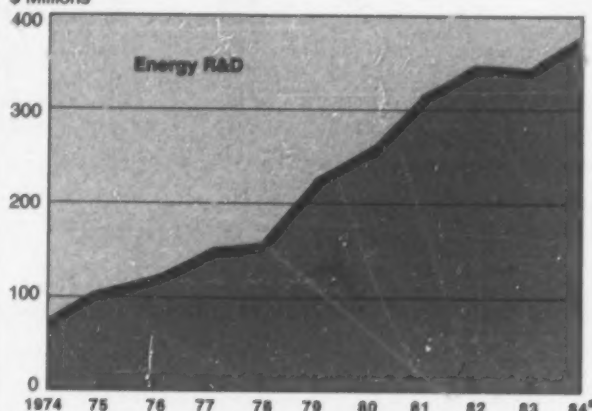
1983 chemical R&D spending^a = \$4.0 billion



^a Excludes basic research on drugs. Source: National Science Foundation

Chemical firms' outlays for energy R&D have risen fivefold since 1974 ...

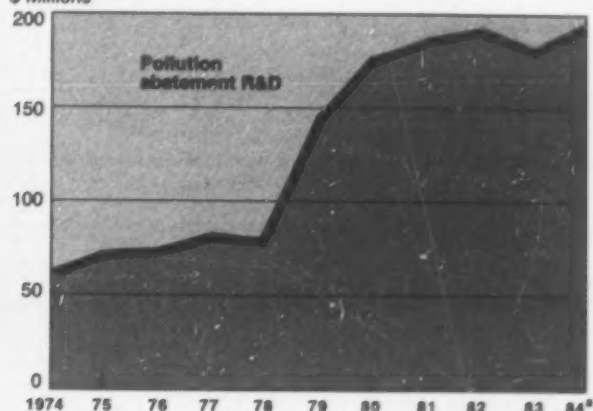
\$ Millions



a NSF estimates. Source: National Science Foundation

... and spending for pollution control has more than tripled

\$ Millions



APPLIED R&D BY ALL INDUSTRY ON CHEMICALS: Drugs capture a bigger share of total

\$ Millions	1983	1981	1979	1977	1976	1975	1974	1973	1972	1971	1970	1969
Industrial chemicals	\$1146	\$1020	na	\$ 822	\$ 728	\$ 665	\$ 589	\$ 489	\$ 451	\$ 457	\$ 442	\$ 417
Plastics, rubber, and fibers	1360	1315	\$ 881	747	674	588	589	511	453	511	521	482
Agricultural chemicals	587	487	292	236	205	176	137	114	108	130	126	104
Other chemicals	940	1081	na	220	246	198	246	229	238	218	223	210
Drugs	2601	1837	1089	959	863	783	683	605	531	535	474	417
TOTAL	\$6634	\$5740	\$3648	\$2984	\$2736	\$2410	\$2246	\$1948	\$1781	\$1851	\$1786	\$1630

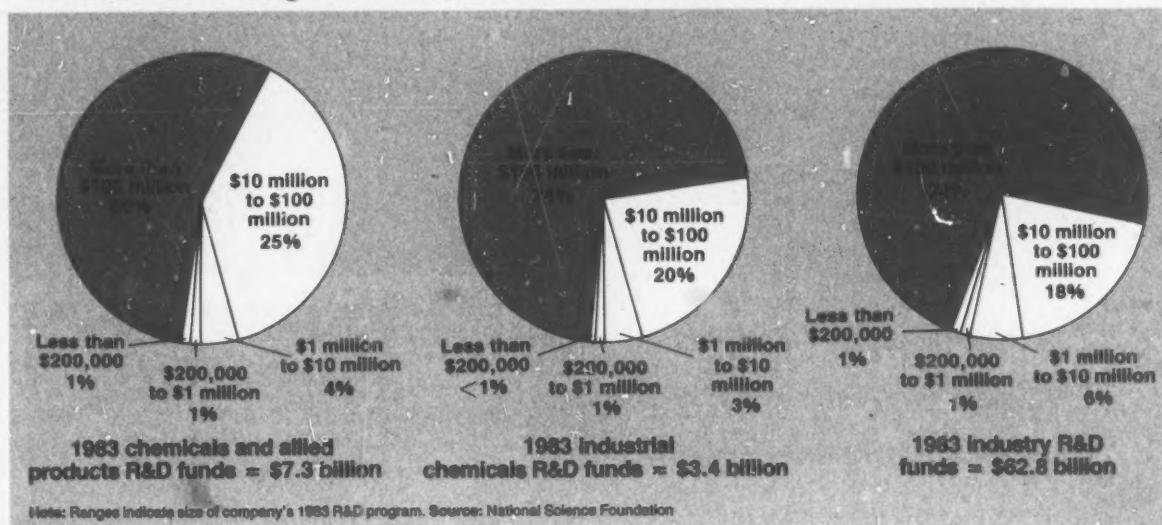
Note: No data for 1976, 1980, and 1982. na = not available. Source: National Science Foundation

APPLIED R&D ON CHEMICALS AND DRUGS: Drug and chemical firms dominate drug research

Industry	Product field (\$ millions)									
	1983		1981		1979		1977		1976	
	Chemicals	Drugs	Chemicals	Drugs	Chemicals	Drugs	Chemicals	Drugs	Chemicals	Drugs
Chemicals and allied products	\$2536	\$2207	\$2402	\$1559	\$1604	\$1020	\$1327	\$903	\$1192	\$817
Industrial chemicals	1746	307	1615	203	1086	136	806	101	711	84
Drugs	250	1817	303	1301	205	840	131	756	130	703
Other chemicals	540	83	484	55	313	42	390	46	351	30
Petroleum refining	531	a	520	0	283	a	192	7	188	4
Rubber products	a	a	a	0	75	0	44	a	31	a
Stone, clay, and glass products	73	a	60	7	37	0	34	0	51	5
Food and kindred products	27	a	45	a	28	a	26	a	25	5
Textiles and apparel	a	0	a	0	a	0	a	0	a	0
Lumber, wood products, and furniture	a	0	15	0	5	0	10	0	8	0
Paper and allied products	31	0	46	0	36	0	22	a	13	a
Primary metals	81	a	79	0	a	0	55	a	47	0
Ferrous metals and products	27	a	23	0	a	0	14	0	13	0
Nonferrous metals and products	54	a	57	0	a	0	41	a	34	0
Fabricated metal products	101	0	79	0	65	a	47	3	42	4
Machinery	a	a	92	0	26	0	24	a	15	a
Electrical equipment	215	4	124	a	62	a	49	4	56	6
Motor vehicles and motor vehicle equipment	126	0	97	0	68	0	48	0	42	0
Other transportation equipment	a	a	22	1	19	0	15	0	a	0
Aircraft and missiles	44	4	52	0	25	0	15	0	27	0
Professional and scientific instruments	36	a	a	a	65	54	43	35	37	30
Other manufacturing industries	21	0	12	0	26	0	12	0	10	0
Nonmanufacturing industries	78	0	77	0	a	a	58	a	62	a
TOTAL	\$4033	\$2601	\$3903	\$1837	\$2559	\$1089	\$2024	\$959	\$1837	\$877

a Not separately available but included in total. Note: No data for 1976, 1980, and 1982. Source: National Science Foundation

Firms with R&D budgets under \$10 million do less than 10% of industrial R&D

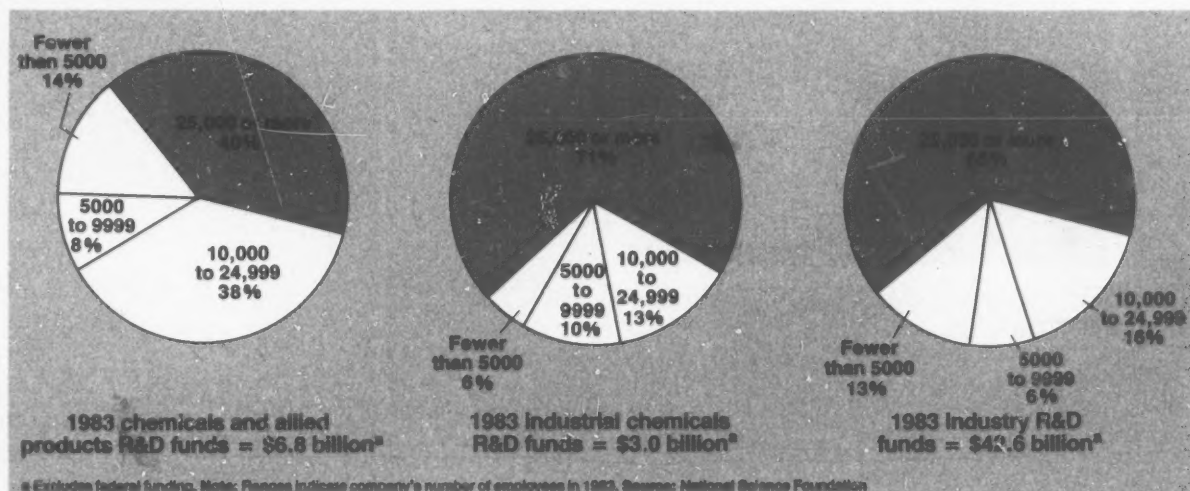


R&D SCIENTISTS AND ENGINEERS IN INDUSTRY: Chemical firms employ 13% of total

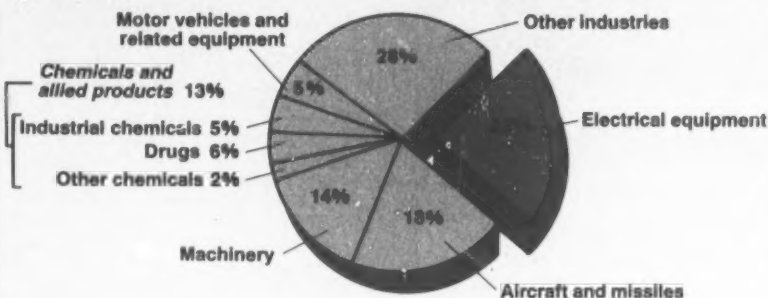
Thousands ^a	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Chemicals and allied products	67.5	66.0	61.6	54.7	51.4	50.0	48.3	46.4	44.4	45.2	41.8
Industrial chemicals	26.7	27.2	25.9	21.6	20.9	21.4	21.3	20.6	20.1	21.1	19.1
Drugs	30.3	28.2	25.6	23.3	21.6	20.9	19.5	17.8	16.6	15.6	14.0
Other chemicals	10.5	10.6	10.1	9.8	8.9	7.9	7.5	8.0	7.8	8.5	8.7
Other industries	470.3	456.1	446.2	433.1	399.2	373.9	356.1	336.4	320.0	318.1	318.2
TOTAL	537.8	522.1	509.8	487.8	450.6	423.9	404.4	382.8	364.4	363.3	360.0

^a Full-time equivalent. Note: Data as of January of each year. Source: National Science Foundation

Largest slice of R&D spending is done by firms with 25,000 or more employees



Biggest percentage of industrial R&D scientists and engineers work for electrical equipment firms



1984 total industrial R&D scientists and engineers* = 537,800

* Full-time equivalent. Source: National Science Foundation

R&D SCIENTISTS AND ENGINEERS PER 1000 EMPLOYEES: Up sharply for drug firms

	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
Chemicals and allied products	53	51	44	42	42	43	42	40	41	40	39	39	41
Industrial chemicals	45	44	37	36	36	38	38	36	38	37	36	34	35
Drugs	82	74	66	60	62	65	62	64	59	57	57	60	65
Other chemicals	37	36	33	30	27	27	29	28	29	30	29	31	31
All industry	35	33	29	27	27	27	27	27	26	25	24	24	26

Source: National Science Foundation

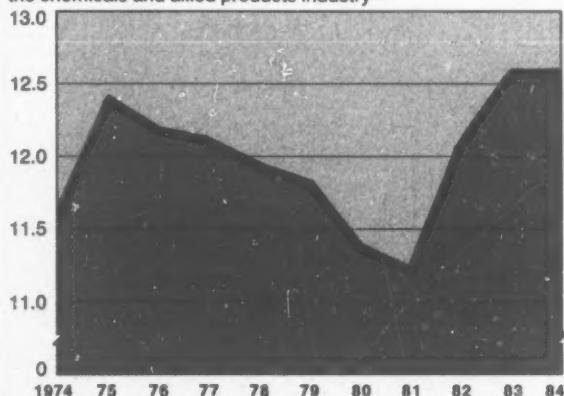
COST PER INDUSTRIAL R&D SCIENTIST OR ENGINEER: Below average for chemical industry

\$ Thousands	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
Chemicals and allied products	\$109.2	\$104.4	\$ 96.6	\$87.4	\$79.6	\$72.8	\$67.6	\$66.5	\$60.9	\$56.3	\$51.1
Industrial chemicals	126.5	124.3	118.0	103.4	92.8	84.2	79.6	74.7	67.5	63.5	58.6
Drugs	a	a	a	79.2	71.4	64.8	59.9	63.4	60.9	54.3	51.5
Other chemicals	a	a	a	66.5	66.5	61.6	53.8	50.8	43.2	45.3	34.0
All industry	\$118.5	\$112.4	\$103.9	\$94.9	\$87.4	\$80.4	\$75.8	\$72.2	\$66.5	\$63.3	\$59.2

a Not separately available but included in chemicals and allied products. Source: National Science Foundation

Share of R&D scientists and engineers in chemical industry unchanged last year

% of total industrial R&D scientists and engineers in the chemicals and allied products industry^a



a Full-time equivalent, as of January of each year. Source: National Science Foundation

CHEMISTS IN INDUSTRY: Nearly half are employed by chemical and drug companies

Industry	% of industrial chemists			
	All chemists	B.S.	M.S.	Ph.D.
Chemical	33%	27%	28%	40%
Pharmaceutical ^a	16	15	18	16
Petroleum	6	4	6	7
Coatings	6	8	7	4
Food	4	5	5	3
Metals and minerals	3	3	3	2
Rubber	2	3	2	2
Other manufacturing	23	24	23	22
Nonmanufacturing	7	10	8	5

a includes personal-care products. Source: 1985 ACS survey

4 R&D/Universities and colleges

Funding shows biggest gain since 1981

CHARACTER OF UNIVERSITY R&D SPENDING: Basic research got biggest increase last year

\$ Millions	1984 ^a	1983	1982	1981	1980	1979	1978 ^b	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Basic research	\$5870	\$5214	\$4851	\$4576	\$4026	\$3612	\$3176	\$2800	\$2549	\$2410	\$2154	13%	11%
Applied research	2280	2095	1995	1865	1691	1465	1213	1067	1015	851	736	9	12
Development	475	436	415	377	343	284	236	200	164	148	133	9	14
TOTAL	\$8625	\$7745	\$7261	\$6818	\$6060	\$5361	\$4625	\$4067	\$3729	\$3409	\$3023	11%	11%

^a Estimated. ^b Estimated, based on data from Ph.D.-granting institutions only. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

SOURCE OF UNIVERSITY R&D FUNDS: Federal government provides nearly two thirds

\$ Millions	1984 ^a	1983	1982	1981	1980	1979	1978 ^b	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Federal government	\$5500	\$4960	\$4749	\$4559	\$4094	\$3595	\$3059	\$2726	\$2512	\$2288	\$2032	11%	10%
Industry	425	370	326	288	235	193	170	139	123	113	96	15	16
Universities	2080	1830	1683	1523	1323	1200	1037	888	810	749	677	14	12
Other sources	620	585	503	448	408	373	359	314	284	259	218	6	11
TOTAL	\$8625	\$7745	\$7261	\$6818	\$6060	\$5361	\$4625	\$4067	\$3729	\$3409	\$3023	11%	11%

^a Estimated. ^b Estimated, based on data from Ph.D.-granting institutions only. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

FIELDS OF UNIVERSITY R&D SPENDING: Physical sciences funding up strongly in 1984

\$ Millions	1984	1983	1982	1981	1980	1979	1978 ^a	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Physical sciences	\$ 990 ^b	\$ 890.0	\$ 822.1	\$ 766.5	\$ 677.6	\$ 601.9	\$ 496.4	\$ 423.5	\$ 379.4	\$ 350.3	\$ 333.5	11%	11%
Chemistry	375 ^b	335.9	310.7	285.5	244.5	206.4	183.1	159.4	140.1	120.7	115.8	12	12
Physics	455 ^b	407.3	363.3	356.9	322.1	292.0	235.1	201.7	183.1	173.5	169.3	12	11
Engineering	1250 ^b	1100.9	1024.3	960.0	864.0	768.4	601.1	496.5	431.7	380.9	346.9	14	14
Total R&D spending	\$8625	\$7745.0	\$7260.6	\$6818.3	\$6060.1	\$5361.4	\$4624.7	\$4067.0	\$3729.0	\$3408.7	\$3022.6	11	11

^a NSF estimates, based on data from Ph.D.-granting institutions only. ^b C&EN estimates. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

FEDERALLY FINANCED R&D SPENDING AT UNIVERSITIES: Uniform growth in 1985

\$ Millions	1984	1983	1982	1981	1980	1979	1978 ^a	1977	1976	1975	1974	Annual change	
												1983-84	1974-84
Physical sciences	\$ 780 ^b	\$ 699.3	\$ 649.6	\$ 618.6	\$ 554.5	\$ 490.7	\$ 392.3	\$ 338.8	\$ 305.4	\$ 285.0	\$ 270.2	12%	11%
Chemistry	280 ^b	249.0	231.5	216.6	189.3	156.5	138.0	121.5	107.9	92.7	88.7	12	12
Physics	380 ^b	340.7	305.9	308.5	279.7	252.5	199.2	171.9	156.1	149.9	146.5	12	10
Engineering	820 ^b	735.3	697.2	661.6	594.6	526.4	407.5	336.7	290.5	259.4	239.3	12	13
Total R&D spending	\$5500	\$4959.6	\$4749.3	\$4559.0	\$4093.6	\$3595.3	\$3058.7	\$2726.1	\$2511.9	\$2288.1	\$2032.2	11%	10%

^a NSF estimates, based on data from Ph.D.-granting institutions only. ^b C&EN estimates. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

TOP 12 UNIVERSITIES IN R&D SPENDING: MIT, Berkeley at top in chemical outlays

\$ Millions, fiscal 1983	Physical sciences	Chemistry ^a	Engineering	Environmental sciences	Life sciences	Math and computer sciences	Other sciences ^b	Total
Johns Hopkins U	\$57.3 ^c	\$4.6 ^c	\$81.4 ^c	\$31.1 ^c	\$73.6 ^c	\$49.3 ^c	\$10.4 ^c	\$303.1 ^c
Massachusetts Inst. of Technology	56.7	8.9	82.5	11.3	26.5	10.4	13.0	200.3
U of Wisconsin, Madison	15.6	5.3	17.6	13.3	95.1	7.0	19.6	168.3
Stanford U	25.7	6.6	50.2	3.1	38.5	10.6	4.9	163.0
U of Minnesota	10.7	5.0	14.0	3.3	117.5	2.3	8.4	156.2
Cornell U	24.6 ^c	5.7 ^c	23.1 ^c	4.6	89.3 ^c	2.7	9.1 ^c	153.3
U of California, San Diego	17.4	3.9	0.9	78.8	44.1	2.3	3.5	147.0
U of Washington	7.7	2.2	8.2	16.7	79.3	2.4	19.2	133.5
U of Michigan	9.5	2.2	19.8	6.4	62.2	3.0	31.9	132.9
U of California, Berkeley	21.6	7.9	25.2	2.5	50.2	3.0	16.5	119.0
Harvard U	16.4 ^c	6.9 ^c	1.4 ^c	6.2 ^c	85.5 ^c	2.3 ^c	6.8 ^c	118.6 ^c
Columbia U, main division	11.6	4.3	5.9	21.1	65.6	2.5	6.1	113.8

a Included in physical sciences. b Includes social sciences, psychology, and other sciences not listed separately. c Estimated. Source: National Science Foundation

TOP 12 UNIVERSITY R&D CENTERS:^a Some concentrate solely on physical sciences

\$ Millions, fiscal 1983	Physical sciences	Engineering	Environmental sciences	Math and computer sciences	Total ^b
Lawrence Livermore National Lab	\$159.0	\$304.7	\$20.2	\$64.1	\$564.2
Los Alamos National Lab	265.9	168.2	14.6	45.4	544.4
Jet Propulsion Lab	70.5	180.1	33.4	152.0	436.0
Argonne National Lab	63.1	108.6	27.9	3.0	215.2
Lincoln Lab	37.2	136.6	0	19.8	193.7
Brookhaven National Lab	116.7	28.1	9.4	0.6	176.9
Plasma Physics Lab	135.3	0	0	0	135.3
Lawrence Berkeley Lab	77.6 ^c	12.3 ^c	13.2 ^c	4.1 ^c	130.8 ^c
Fermi National Accelerator Lab	130.4	0	0	0	130.4
Stanford Linear Accelerator Center	78.2	0	0	0	78.2
National Center for Atmospheric Research	4.4	0	34.6	0	39.0
Ames Laboratory	11.8	6.4	0.1	0.6	19.0

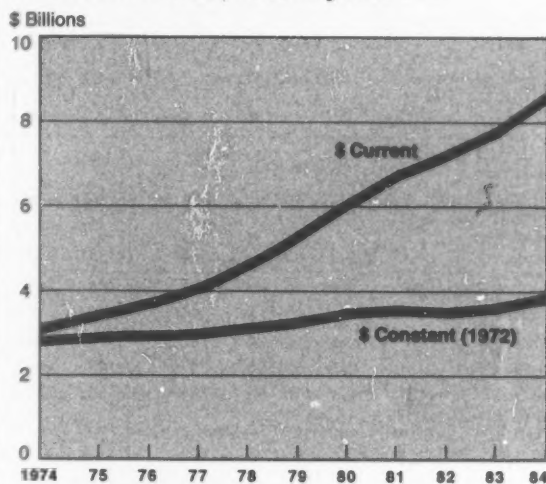
a Data for university-administered federally funded R&D centers. b Includes life sciences and other sciences not listed separately. c Estimated. Source: National Science Foundation

ACADEMIC SCIENTISTS AND ENGINEERS: 6% are chemists or chem engineers

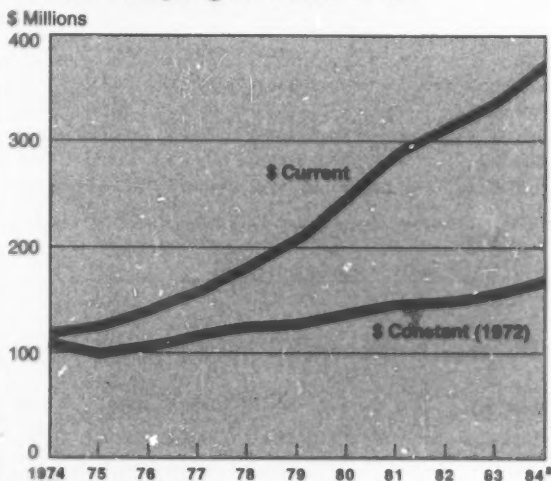
Thousands of scientists and engineers ^a	1984	1983	1982	1981	1980	1979	1977
TOTAL							
Physical scientists	35.5	34.8	34.5	34.1	33.6	32.8	32.1
Chemists	18.8	18.3	18.1	18.1	17.6	17.7	17.1
Physicists	13.6	13.6	13.3	12.9	13.0	12.8	12.5
Engineers	39.0	37.7	36.4	34.9	33.7	31.0	30.1
Chemical	2.5	2.4	2.3	2.3	2.4	2.0	1.9
Other scientists	296.0	285.4	278.2	265.6	255.9	243.9	235.7
TOTAL	370.5	358.9	349.1	334.6	324.2	307.6	297.9
FULL TIME ONLY							
Physical scientists	29.0	28.5	28.6	28.2	28.0	27.9	27.6
Chemists	15.1	14.8	14.7	14.8	14.3	14.7	14.5
Physicists	11.5	11.4	11.4	11.0	11.3	11.3	11.1
Engineers	29.4	28.8	28.0	27.0	26.5	24.7	24.1
Chemical	2.0	2.0	1.9	1.9	1.9	1.7	1.7
Other scientists	223.2	216.8	212.0	204.5	200.5	189.6	184.6
TOTAL	281.6	274.1	268.6	259.7	255.0	242.2	236.3

a In January. Note: Data not available for 1979. Source: National Science Foundation

Spending for academic R&D, in real terms, has risen in most recent years . . .



. . . and spending for R&D in chemistry has been steadily higher since 1975



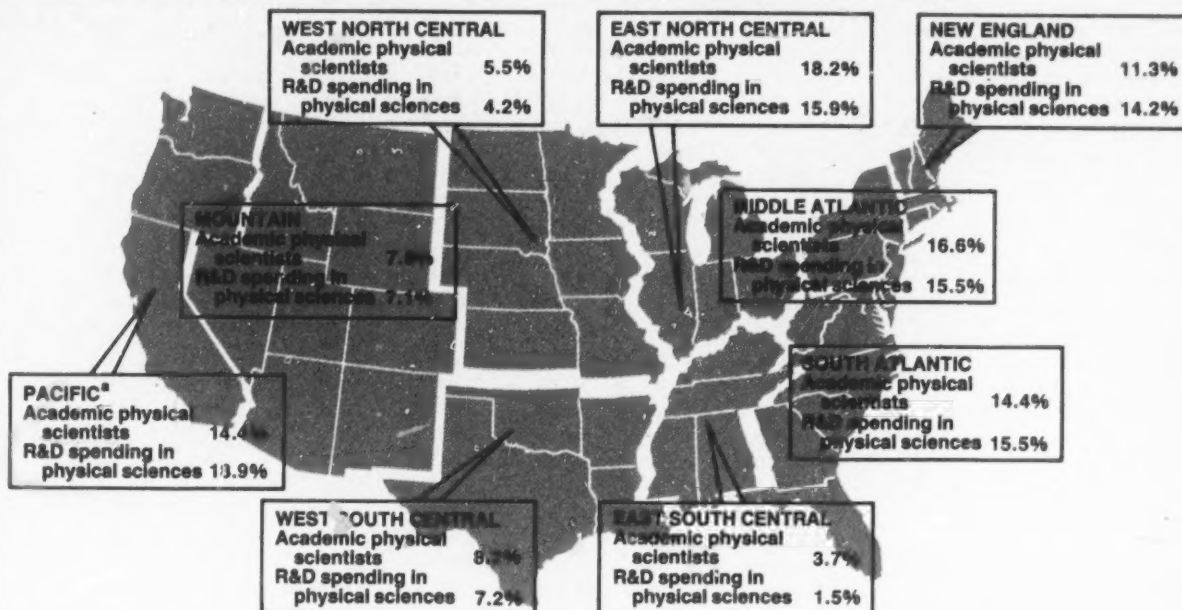
a C&EN estimates. Note: Data for institutional fiscal years. Source: National Science Foundation

SCHOOLS SPENDING MOST ON CHEMICAL R&D: Top 20 spent a third of total in 1983

\$ Thousands	Total spending				Federally financed spending			
	1983	1982	1981	1980	1983	1982	1981	1980
1 Massachusetts Inst. of Technology	\$ 8,914	\$ 9,792	\$ 8,222	\$ 6,764	\$ 8,374	\$ 9,096	\$ 7,572	\$ 6,311
2 U of California, Berkeley	7,945	6,283	6,553	6,022	7,467	5,891	6,008	5,801
3 California Inst. of Technology	6,994	6,136	6,901	6,328	6,554	5,809	6,196 ^a	5,630
4 Harvard U	6,898 ^a	5,512 ^a	6,123 ^a	4,797 ^a	5,224	4,174	4,837	3,631
5 Stanford U	6,589	6,634	5,564	4,788	5,968	5,893	5,337	4,609
6 U of Texas, Austin	5,938	4,843	4,779	3,970	3,527	2,781	3,017	2,564
7 U of Illinois, Urbana	5,886	6,422	5,239	4,261	4,668	4,763	3,847	3,424
8 Cornell U	5,717 ^a	6,239 ^a	4,618	3,808	4,766	5,437	4,062	3,404
9 Indiana U	5,551	5,341	3,637	3,147	4,642	4,237	3,042	2,635
10 U of California, Los Angeles	5,496	5,187	4,420	4,159	5,047	4,978	4,127	4,017
Total, first 10 institutions	65,928	62,389	56,056	48,044	56,237	52,859	47,845	41,826
11 U of Wisconsin, Madison	5,310	4,567	4,122	3,976	3,693	3,404	3,134	2,944
12 U of Massachusetts, Amherst	5,162	4,364	3,230	1,889	3,336	2,773	2,067	1,632
13 U of Minnesota	4,999	4,297	4,260	2,642	3,726	3,377	3,494	2,143
14 U of Pennsylvania	4,982	3,068	3,386	3,688	4,037	2,745	3,073	3,143
15 Texas A&M U	4,963	4,521	4,069	4,097	3,327	2,823	2,793	2,945
16 U of Chicago	4,798 ^a	4,396 ^a	4,139 ^a	3,958 ^a	3,998	3,716	3,719	3,558
17 Pennsylvania State U	4,729	3,564	3,413	2,973	4,236	3,222	2,773	2,527
18 Johns Hopkins U	4,592 ^a	4,721	4,066	4,652	3,604 ^a	3,800	3,881	4,444
19 Purdue U	4,542	4,459	4,600	3,596	3,966	3,946	3,715	3,151
20 U of Maryland, College Park	4,334	4,009	3,109	2,766	2,834	3,068	2,418	2,292
Total, first 20 institutions	114,339	104,355	94,450	82,281	92,994	85,733	78,912	70,605
21 Columbia U, main division	4,281	4,700	3,564	4,437	4,279	4,365	3,471	4,054
22 U of Notre Dame	4,022	4,020	3,855	3,457	3,867	3,866	3,738	3,328
23 U of California, San Diego	3,910	3,894	4,430	4,425 ^a	3,490	3,506	3,933	4,375 ^a
24 Lehigh U	3,664	2,584	1,680	1,066	1,498	1,189	1,063	480
25 U of Utah	3,638	3,364	3,076	2,817	3,085	2,858	2,720	2,373
26 Ohio State U	3,616 ^a	2,907	3,227	2,654	2,786 ^a	2,355	2,679	2,144
27 Princeton U	3,509	3,062	2,513	2,065	2,642	2,485	2,142	1,646
28 U of Nebraska, Lincoln	3,431 ^a	3,217	2,175	2,289	1,995 ^a	1,995	1,757	1,909
29 Northwestern U	3,413	3,026	2,995	2,367	3,012	2,711	2,813	2,221
30 U of Southern California	3,404	2,401	2,345	2,313	2,456	1,717	1,639	1,773
Total, first 30 institutions	151,227	137,530	124,310	110,165	122,104	112,790	104,867	94,906
31 Georgia Inst. of Technology	3,401	3,327	3,660	3,655	2,032	1,800	2,030	2,118
32 U of Oregon, main	3,351	2,971	1,389	1,119	2,686	2,530	1,235	1,035
33 Yale U	3,341	2,875	2,781	2,023	3,008	2,599	2,609 ^a	1,866
34 U of Colorado	3,302	3,492	4,047	3,332	2,695	2,755	3,146	2,605
35 U of Pittsburgh	3,267	2,714	2,039	1,641	2,833	2,188	1,581	1,366
36 U of Rochester	3,167	3,123	2,966	2,089	2,800	2,774	2,553	1,687
37 Arizona State U	3,062	2,323	2,153	1,449	2,124	1,996	1,958	1,365
38 U of Oklahoma	2,890	2,306	1,399	1,275	1,453	1,067	674	617
39 U of South Carolina	2,721	2,483	1,087 ^b	970 ^a	2,221	1,865	902 ^b	816 ^a
40 U of Connecticut	2,720	2,049	1,748	1,300	1,445	1,113	1,022	773
Total, first 40 institutions	182,449	165,193	147,579	129,018	145,401	133,467	122,577	109,156
41 Michigan State U	2,714	2,493	2,178	1,638	1,995	1,832	1,541	1,157
42 Wayne State U	2,645	2,656	2,261	2,163	1,813	1,799	1,636	1,640
43 Rensselaer Polytech Inst.	2,640	2,975	2,286	1,551	1,379	1,724	1,310 ^a	962
44 State U of New York, Stony Brook	2,607	2,783	2,691	1,966	1,809	1,901	2,080	1,632
45 State U of New York, Buffalo	2,589	2,242	2,203	1,665	1,736	1,528	1,626	1,163
46 Florida State U	2,500	2,959	3,012	2,791	1,115	1,124	1,463	1,313
47 Colorado State U	2,478	2,479	2,385	1,973	2,055	2,230	2,079	1,717
48 U of Houston, University Park	2,423	1,816	1,773	1,371	1,117	909	891	599
49 U of North Carolina, Chapel Hill	2,397	2,240	2,016	1,789	2,381	2,218	1,936	1,752
50 U of Florida	2,347	2,248	2,302	2,283 ^a	1,325	1,341	1,156	1,214 ^a
Total, first 50 institutions	\$207,789	\$190,084	\$170,686	\$148,208	\$162,126	\$150,073	\$138,295	\$122,305
NATIONAL TOTAL	\$335,853	\$310,668	\$285,520	\$244,454	\$248,990	\$231,489	\$216,630	\$189,287

a Estimated. b Imputed. Note: Data for institutional fiscal years. Source: National Science Foundation

Schools in Pacific region account for nearly 20% of total academic R&D in physical science, but employ fewer physical scientists than schools in several eastern areas



Key to map: Using the Middle Atlantic states as an example, 16.6% of all physical scientists employed at U.S. Ph.D.-granting universities and colleges are located in this geographical area and 15.5% of all R&D expenditures in the physical sciences by all universities and colleges are made in this area. * Includes Alaska, Hawaii, and outlying areas. **Note:** Data are based on 20,127 physical scientists employed at Ph.D.-granting universities and colleges in the U.S. as of January 1984, and R&D expenditures of \$690.0 million in the physical sciences during 1983 fiscal year of all universities and colleges. **Source:** National Science Foundation

CHEMICAL DEGREES: Small declines expected for B.S., M.S. graduates in 1984-85

Academic year	Degrees awarded in chemistry ^a			Degrees awarded in chemical engineering		
	Bachelors	Masters	Ph.D.s	Bachelors	Masters	Ph.D.s
1965-66	9,735	1839	1571	2848	994	354
1966-67	9,872	1831	1744	2869	949	305
1967-68	10,847	2014	1757	3211	1156	367
1968-69	11,807	2070	1941	3557	1136	409
1969-70	11,617	2146	2208	3720	1045	438
1970-71	11,183	2284	2160	3615	1100	406
1971-72	10,721	2259	1971	3663	1154	394
1972-73	10,226	2230	1882	3636	1051	397
1973-74	10,525	2138	1828	3454	1045	400
1974-75	10,649	2006	1824	3142	990	346
1975-76	11,107	1796	1623	3203	1031	308
1976-77	11,322	1775	1571	3581	1086	291
1977-78	11,474	1892	1525	4615	1237	259
1978-79	11,643	1765	1518	5655	1149	304
1979-80	11,446	1733	1551	6383	1271	284
1980-81	11,347	1654	1622	6527	1267	300
1981-82	11,062	1751	1722	6740	1285	311
1982-83 ^b	11,261	1739	1705	7850	1630	390
1983-84 ^b	11,261	1744	1720	7680	1770	410
1984-85 ^b	11,148	1739	1731	7600	1760	410

^a Data do not include biochemistry and geochemistry. ^b ACS estimates. **Source:** Department of Education's National Center for Education Statistics

GRADUATE SCIENCE STUDENTS: Chemists and chem engineers account for 7%

Thousands	1983	1982	1981	1980	1979	1978	1977
TOTAL							
Physical sciences	27.7	26.5	25.8	25.4	24.9	24.7	24.8
Chemistry	16.5	15.8	15.2	15.1	14.9	14.8	14.6
Physics	10.5	10.0	9.9	9.6	9.3	9.2	9.5
Engineering	86.0	78.2	74.1	70.1	67.2	64.3	64.4
Chemical	7.4	6.1	6.3	5.9	5.4	5.2	5.1
Metallurgical and materials	3.3	3.0	3.0	2.8	2.7	2.5	2.5
Petroleum	0.7	0.6	0.5	0.5	0.4	0.4	0.4
Life sciences	91.3	90.7	90.9	90.7	87.5	85.9	83.3
Biochemistry	4.2	4.1	4.0	4.0	3.9	4.0	3.8
Other sciences ^a	153.3	151.4	148.9	147.5	141.0	134.9	134.1
TOTAL	358.3	346.8	340.0	333.7	320.6	309.8	306.6
FULL TIME ONLY							
Physical sciences	24.5	23.3	22.6	22.3	21.8	21.5	21.7
Chemistry	14.5	13.7	13.2	13.1	12.8	12.7	12.6
Physics	9.3	8.9	8.8	8.5	8.3	8.2	8.5
Engineering	53.6	48.7	44.8	41.9	39.3	37.1	36.7
Chemical	5.8	5.5	4.9	4.4	4.2	3.9	3.8
Metallurgical and materials	2.7	2.5	2.4	2.2	2.1	2.0	1.9
Petroleum	0.6	0.5	0.4	0.4	0.3	0.3	0.3
Life sciences	65.2	65.7	67.2	67.7	66.5	65.2	64.3
Biochemistry	4.0	3.8	3.7	3.7	3.6	3.7	3.6
Other sciences ^a	100.3	99.2	99.6	98.6	95.8	92.8	94.8
TOTAL	243.6	236.9	234.2	230.5	223.4	216.6	217.5

^a Includes environmental, mathematical, computer, and social sciences and psychology. **Note:** Data for Ph.D.-granting institutions only. **Source:** National Science Foundation

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JULY 29, 1986

CHEMICAL & ENGINEERING

NEWS

FINAL PROGRAM
ACS meeting in Chicago
Page 33

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News of the Week

■ Academic science research facilities are in a sorry state; how to fund modernization was subject of NAS meeting. **Page 4**

■ U.S. chemical company earnings in second quarter continue decline from year-earlier level. **Page 5**

■ National Transportation Safety Board calls for federal regulations regarding hazardous materials in railroad yards. **Page 6**

■ Chemical weapons production will get the go-ahead if conference committee deletes from authorization bill requirement that NATO allies must agree to deploy them. **Page 6**

■ Coalition of Indian professionals in U.S. hopes to raise \$3 million for a clinic and research center for Bhopal victims. **Page 6**

Government

The federal government would be required to notify both past and present workers exposed to chemicals that might cause chronic diseases under Pennsylvania Congressman's bill. **Page 15**

Science

Students, senior scientists discuss ethical and social dimensions of scientific decision making at Student Pugwash conference. **Page 18**

Education

All members of U.S. team win medals in International Chemistry Olympiad held in Bratislava, Czechoslovakia. **Page 23**

Industrial Associates Program at Purdue engages both academic and industry scientists in projects for mutual benefit. **Page 24**

Books

"Normal Accidents" by Charles Perrow examines certain high-risk technologies with an eye toward abandoning nuclear power. **Page 30**

Final Program

Program includes complete listing of the scientific papers to be presented at the ACS annual meeting in Chicago. **Page 33**

Cover: Union Carbide's Linde division air separation plant at Niagara Falls, N.Y.

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Business

Fortunes of industrial gases are not all the same: Nitrogen demand is high, but call for oxygen and hydrogen is at a standstill and carbon dioxide is affected by lack of low-cost feedstock. **Page 9**

Industrial Gases: Producers Face Mixed Demands

Demand for nitrogen surges, but that for oxygen and hydrogen has stalled; supply of carbon dioxide is hurt by inadequate low-cost feedstock

Bruce F. Greek, C&EN Houston

Producers of the various industrial gases are coping with several different demand pressures. For some gases, such as nitrogen and argon (a small-volume but important gas), demand is strong, and producers are running their plants for optimum production. For certain other gases, such as oxygen and hydrogen, demand has become lackluster. And for carbon dioxide, the problem of inadequate low-cost feedstock holds down the amount that producers can sell.

For those gases whose demand is increasing, producers not unexpectedly are adding to capacity and raising prices. However, price increases,

most of which were effective May 1, have been modest, probably just covering the increased costs of electricity, a major expense in operating air separation plants used to produce oxygen, nitrogen, and argon. Programs to reduce costs also have been put in place, spurred by the declines in demand during the past recession, which led to low plant operating rates and to the closing of considerable capacity. These

Key Chemicals

cost-reduction programs have tended to help profitability when price increases covered just a part of increased costs.

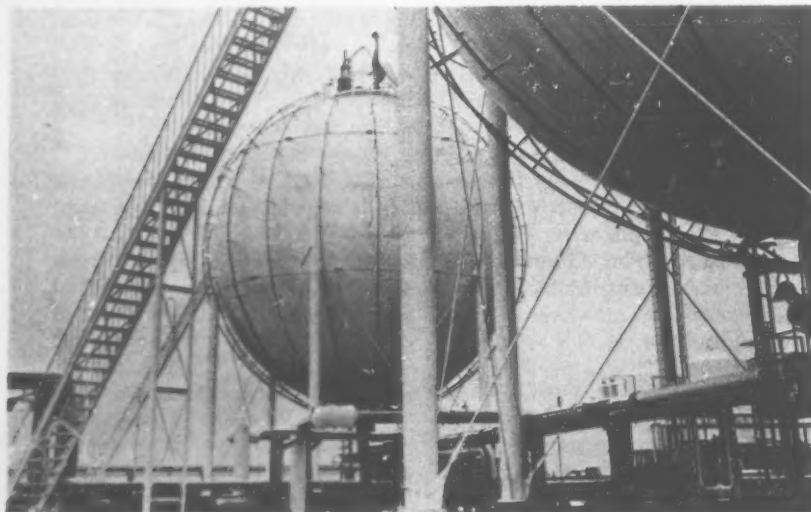
Some of the shut-down capacity has remained closed since the recession, and some additional capacity has since been shuttered, especially captive capacity located adjacent to steel mills. Because these capacity shutdowns involved rela-

tively large units, the present capacity to produce industrial gases remains below prerecession levels in spite of capacity expansions in the past year. Few new air-separation plants are under construction to supply the merchant part of the industry, even with the increase in plant operating rates, because returns haven't yet risen to levels needed to cover the investments—except in special areas such as supplying the electronics industry.

Merchant volumes of these gases will continue to rise at modest rates—in the range of 4 to 8% annually, on the average—for the rest of the 1980s. Additional plants will be built during this time to satisfy growth in regional demand. But few, if any, shut-down plants of any size will be moved to new locations, because such plants are less energy-efficient than are new plants and because it is costly to move them. Unfortunately, the old plants will not be scrapped very rapidly, and as a result, the apparent capacity will remain excessive and operating rates will remain understated for the industry.

Prices received by producers for the gases will continue to rise slowly. In addition to the competition among gas producers, the possibility that customers might build their own gas-producing plants will continue to hold down prices. In addition, the increasingly higher quality of gases required for the electronics industry and other specialized uses will have to be paid for by consumers. The higher prices that result from supplying higher-quality gases will justify new capacity through the 1980s.

For details of the near-term outlook for the major-volume industrial gases, please see the following pages.

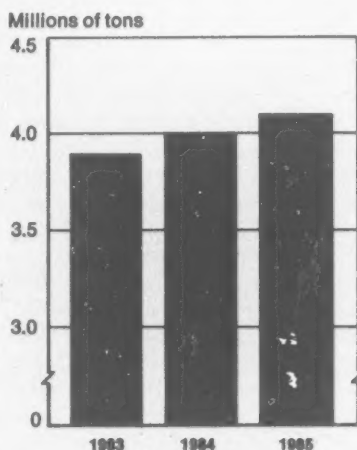


Air Products & Chemicals' liquid hydrogen storage tanks in New Orleans

Carbon dioxide

- **Demand steady**
- **Supply tight**
- **Prices holding**

PRODUCTION (nonoilfield)



MAJOR PRODUCERS

Air Products & Chemicals, Airco Industrial Gases, Chemetron Corp., Liquid Carbonic, UGI Corp.

HOW MADE

Recovered as coproduct in ammonia production and in manufacture of ethanol by fermentation, obtained from refinery and chemical operations and from natural wells

MAJOR USES (nonoilfield)

Refrigeration 40%, beverage carbonation 20%, enhanced oil recovery 10%, chemical manufacture 10%, metals fabrication 10%

FOREIGN TRADE

Exports—negligible, imports—1 to 2% of demand

PRICE

About \$65 per ton

Merchant sales and production of carbon dioxide in 1985 are expected to grow about 5%, subject to availability of carbon dioxide sources. This growth would bring reported production to 4.1 million tons, or possibly a little more, up from slightly less than 4 million tons reported as preliminary estimates for 1984.

Whatever the reported production of carbon dioxide actually totals in 1985, it certainly will be far less than all production of this industrial gas. By far the largest quantity of carbon dioxide produced industrially comes from natural gas wells. Most of it is pipelined to oil fields where it is used to increase oil production through the enhanced oil recovery (EOR) technology of carbon dioxide flooding of underground formations containing petroleum.

Merchant production of carbon dioxide continues to be limited by available sources of raw material. About three fourths of merchant carbon dioxide is recovered as a coproduct in the manufacture of ammonia. Merchant carbon dioxide so obtained doesn't account for all of the carbon dioxide coproduced in making ammonia, because large quantities are consumed, usually on site, to make urea, a fertilizer and an ingredient for making polymeric resins such as the urea-formaldehyde adhesives. Currently, the other major source of carbon dioxide for the merchant market is the coproduct of grain fermentation to make ethanol, most of which is now used as an octane enhancer for gasoline.

Both major sources of carbon dioxide depend on the operation of ammonia and ethanol plants for their primary product. In turn, demand for the primary product depends on fertilizer demand and on tax incentives to make alcohol-gasoline mixtures (gasohol) nearly competitive with unleaded gasoline prices. The minor sources for merchant carbon dioxide from refineries and chemical plants are rather steady sources, but are small as is the

recovery from wells. Availability of feedstock to carbon dioxide plants varies with operation of the source plant.

Capacity to make or recover carbon dioxide seems relatively large in relation to reported production, although no actual capacity estimates are available. Several recovery units have been or are being built adjacent to ethanol plants. These new plants are scheduled to go on stream in 1985 or early 1986. If feedstock is available to operate the newer capacity and to operate existing capacity about as in the past, then production for all of 1985 might be higher than 4.1 million tons. However, feedstock limitations have always prevented full operation of the recovery plants for long term.

As a result of the supply limitations, consumption of carbon dioxide is held down. The largest use, for refrigeration, runs into competition from nitrogen. It's debatable which of these two industrial gases is the more suitable for food freezing; no real resolution of this question has been reached, but each gas (consumed in liquid form) has developed its own niche. The continual growth in sale of "fast foods" helps this use of carbon dioxide and accounts for much of the growth in the merchant sales.

Beverage carbonation accounts for the second largest use of carbon dioxide. Growth in this use likely will be less than average for all merchant carbon dioxide, but it remains a good market with relative stability.

Various industrial uses of carbon dioxide, such as chemical manufacture and metals fabrication, take about 20% of the merchant supply, if the EOR use is excluded. For chemical operations, the largest use is in blanketing. Merchant carbon dioxide used in EOR is less than 10% of the total and is used largely on a spot basis for testing the suitability of a carbon dioxide flood to augment oil production. Future prices of crude oil are important in this use.

Key Chemicals

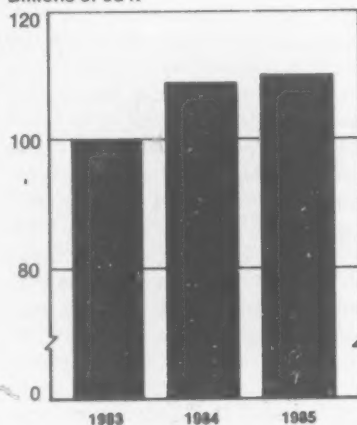


Hydrogen

- **Demand level**
- **Government use down**
- **Prices steady**

PRODUCTION

Billions of cu ft



MAJOR PRODUCERS

Air Products & Chemicals, Airco (BOC Group), Liquid Air, Union Carbide's Linde division

HOW MADE

Reforming of natural gas, recovered as coproduct in production of chemicals, and various small-volume methods

MAJOR END USES

Fats and oils hydrogenation 20%, government (space and weather programs) 20%, electronics manufacture 20%, chemical production 10%, metals treating and processing 10%, petroleum refining 10%

FOREIGN TRADE

Negligible

PRICE

About \$1.25 per 100 cu ft

Merchant hydrogen production and sales in 1985 will about match the 109 billion cu ft produced in 1984. The lack of growth in hydrogen's merchant market stems from shifts in major areas of consumption. Demand is dropping for government uses—especially the space program—metals processing, and chemical manufacturing. Other markets may post gains, however, offsetting some of the declines.

Merchant sales of hydrogen account for 10% or less of total hydrogen production. Far bigger than all merchant sales are such captive uses as making ammonia or methanol and in the various hydrotreating processes involved in petroleum refining. These uses are almost completely supplied by on-site hydrogen production. Because of this captive production, no estimates of the volume of hydrogen involved have been made. Guesses are based on the amount of ammonia and methanol produced each year plus assumptions on the amount of hydrogen required for refinery uses, from which must be subtracted the amount of hydrogen generated in refineries by cracking and reforming processes.

For nonpetroleum refining uses, most hydrogen, probably about 80%, is made by reforming natural gas (methane) using oxygen from the air. Much of the remainder is obtained as a coproduct from the manufacture of chlorine and caustic soda by electrolyzing sodium chloride brine. Because of the large demand for hydrogen in refining, a large part of this hydrogen also is made by reforming natural gas. This "on purpose" production is in addition to the hydrogen traditionally recovered from cracking and reforming.

The consumption pattern for hydrogen is as unclear as its production pattern. Much overlap between captive and merchant hydrogen output occurs. Users of merchant hydrogen always have looming over them the decision whether to buy or to make. Often, hydrogen users make part of their needs, and buy the rest.

The dynamics of overlapping supplies can be illustrated by hydrogen use in refineries. Refiners often buy part of their hydrogen needs until their needs become so large that the addition of another gas reforming unit can be justified. As a result, sales to refiners have been one of the fastest-growing areas for merchant hydrogen producers.

Other markets for hydrogen fit into a few general groups. Hydrogenation of edible fats and oils is estimated to account for about 20% of merchant sales of hydrogen. And practically all of the hydrogen used in the government's space program is purchased. The space program requirements have slipped recently because major work in developing current rocket engines has been completed and because space missions have only begun to increase.

Electronic component manufacture has been and continues to be a fast-growing use of hydrogen. Almost all of this hydrogen comes from merchant producers who commercially provide 99.9999% purity routinely because of the low boiling point of hydrogen. Any higher purity may require a shift to on-site further purification.

Chemical manufacturing (excluding ammonia and methanol) and metals processing are supplied hydrogen by both merchant and captive production, but the hydrogen source of each situation differs. For example, one hydrochloric acid manufacturer might use coproduct hydrogen from chlorine cells, in an entirely captive use of the hydrogen. Cyclohexane producers also may use captive hydrogen, but because most producers are chemical subsidiaries of oil companies, the hydrogen may come from the parent company's refineries. With these many chemical uses growing and declining, this hydrogen market is currently a no-growth area for hydrogen.

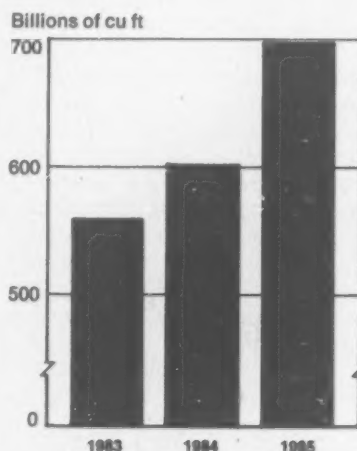
So use of merchant hydrogen in electronics production and by refiners will grow this year and next. But other uses will decline, balancing the growth.



Nitrogen

- Demand up well
- Most uses growing
- Prices firming

PRODUCTION



MAJOR PRODUCERS

Air Products & Chemicals, Airco (BOC Group), Big Three Industries, Liquid Air, Union Carbide's Linde division

HOW MADE

Distillation of liquefied air, pressure swing adsorption using various adsorbents

MAJOR END USES

Blanketing atmosphere for chemical processing 25%, enhanced oil recovery 25%, electronics manufacturing 15%, metals treating and processing 15%, aerospace 5%, freezing meat, poultry, and seafood 5%

FOREIGN TRADE

Negligible

PRICE

50 cents per 100 cu ft

Gain in nitrogen demand contrasts sharply with that for oxygen. Production of nitrogen this year likely will exceed 700 billion cu ft, up about 17% from 1984. This follows a notable but smaller gain of about 8% in 1984.

A large part of this increasing use of nitrogen results from enhanced oil recovery (EOR). During 1984, much of the additional air separation capacity built (some of which did not start up until 1985) was dedicated to EOR use. However, no additional plants for EOR now are under construction, companies say, so the spate of recent capacity gains will be over for at least a year.

Even with growth in most other major uses of nitrogen, the EOR market has been growing so fast that it has become the largest use of nitrogen, according to industry sources. In 1985, EOR will take close to 30% of all nitrogen produced, nosing out chemical manufacturing, where nitrogen is used mainly to provide a blanketing atmosphere.

If crude oil prices decline as expected, EOR use of nitrogen still will hold up well, because EOR seldom involves much additional high-cost drilling of wells. The justification for EOR use of nitrogen depends largely on the costs associated with building the air separation plant, operating the plant, and injecting the nitrogen into the oil well.

Nitrogen competes with carbon dioxide for use in EOR, with carbon dioxide still believed to be much more widely used. Physical properties, particularly the critical pressure of carbon dioxide, can have a major influence on the choice of which gas may be used as an EOR aid in any given field. If pressure, and to some degree, temperature, are not overriding limits to its use, carbon dioxide has advantages over nitrogen. Some of these are low cost and miscibility with crude oil, which lowers crude oil's viscosity to allow better flow through formations.

Uses of nitrogen in chemical production continue to expand, but not at the rates at which they once did. Most of the continuing increase can be attributed to the shift toward making more specialty chemicals, whose synthesis more likely requires an inert blanketing atmosphere than does that of commodity chemicals.

As usual, electronics manufacturing gets major attention from merchant suppliers of nitrogen. The quality requirements have become very high—with 99.9999% nitrogen the standard for the majority of sales—and higher purities are not unusual any more. This kind of quality costs a lot to obtain and maintain, so selling prices of this small segment of merchant nitrogen sales, possibly 3% of the total, are well above those of volume sales. The pressure to obtain even-higher-quality, inert-gas shielding will increase as semiconductor chips become more complex.

Electronics manufacturers so far have been willing to pay for the quality and service in order to get the required nitrogen. Their future needs are keeping suppliers working to improve quality at a cost that likely will keep the profitability of this small part of the business well ahead of the rest.

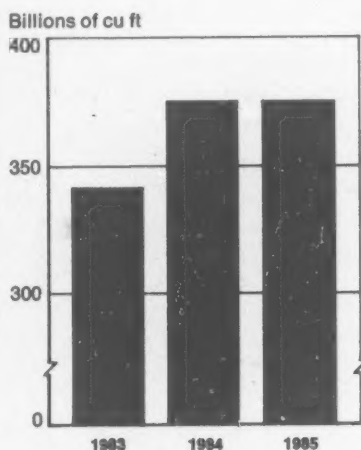
Other uses of nitrogen have less spectacular outlooks, but they also keep adding to total demand. Metals treating and processing and aerospace uses somehow remain close to holding their market shares, even as some individual uses decline. Freezing of meats, poultry, and seafood has been growing steadily with the growth of fast-food outlets. This highly visible consumer area is becoming saturated, and the number of new outlets added each year is declining. However, efforts to increase volume at existing outlets likely will tend to keep demand for these frozen food products growing—and thus for nitrogen as well.

With all significant uses of nitrogen growing substantially this year, it probably will be a banner year for this industrial gas.

Oxygen

- Demand on hold
- Merchant sales up
- Prices up slightly

PRODUCTION



MAJOR PRODUCERS

Air Products & Chemicals, Airco (BOC Group), Big Three Industries, Liquid Air, Union Carbide's Linde division

HOW MADE

Distillation of liquefied air, pressure swing adsorption using various adsorbents

MAJOR END USES

Primary metals manufacturing 55%, chemicals manufacturing 20%, partial oxidation processes 10%, metals fabrication 5%

FOREIGN TRADE

Negligible

PRICES

54 cents per 100 cu ft

For the near term, growth in oxygen production has stalled. Production this year probably will roughly equal that of 1984, about 375 billion cu ft, with the possibility of a slight gain to about 380 billion cu ft. This slowdown follows a 9% annual gain last year.

The problem that oxygen producers face this year involves oxygen's largest use: that of making steel either in basic oxygen furnaces or in electric furnaces. Steel production for all of 1985 will be lackluster at best because of changes in steel demand and sources of supply. An important additional factor in the steel-demand situation will be the careful control of inventories of finished steel, lest the inventories get out of hand as they did at about this time last year.

Basic oxygen furnaces are the largest part of the steel industry's use of oxygen, with most of it supplied by adjacent air separation plants and delivered at relatively low purity by pipeline. Electric furnaces usually produce specialty steels in smaller tonnages and use oxygen supplied mostly by merchant oxygen producers who deliver the oxygen as a liquid and also supply on-site equipment for regasification and handling.

Steel producers using either kind of furnace are facing little or no growth in demand for 1985. Their woes stem from slowdowns in two major markets: the U.S. auto industry and the construction industry. Moreover, imported steel accounts for a growing part of consumption in these two areas as well as in many others.

Because of their locations, specialization, and adaptability, electric furnace steel producers are seeing somewhat better times than are the large producers who generally use basic oxygen furnaces. This situation means better sales for merchant suppliers of oxygen than for those suppliers who operate captive plants.

Merchant oxygen accounts for an estimated 20 to 25% of reported oxygen production, and demand for it like-

ly will grow 5% in 1985. The major uses include chemicals and electronics manufacture, metal fabrication, medical consumption, and many smaller uses. Chemicals manufacture, excluding such uses as partial oxidation processes, also has a substantial share of its oxygen needs supplied by captive air separation plants. Because chemical production will grow at a relatively slow rate in 1985, this use of oxygen also will be up just marginally.

Oxygen supplied for partial oxidation processes also comes largely from merchant producers, although some large consumers have captive sources. Much of this consumption goes to make hydrogen for various subsequent hydrogenation processes. Partial oxidation is expected to continue to grow as an outlet for merchant oxygen. However, the decision whether to make or to buy hangs over each merchant oxygen user.

As with other industrial gases, electronics manufacture is showing one of the better gains in oxygen consumption. Most of this oxygen is supplied by merchant producers. As yet, the total volume remains relatively small, but the requirements in some cases for high purity and the expected growth make this use of high interest to oxygen suppliers.

Many other smaller-volume uses of oxygen are almost entirely supplied by merchant producers. The fortunes of these uses vary with time, technological developments, and outside influences. For example, efforts to reduce costs of medical services as yet have not had a noticeable effect on oxygen demand in medical uses.

Until steel loses its dominance in oxygen consumption, production of oxygen will rise and fall with steel operations. When a steel mill is closed, almost always the adjacent air-separation plant also closes. With no significant additions to steel capacity in view, even in small electric furnaces, oxygen demand will remain on hold for the rest of 1985 and well into 1986.

AUGUST 5, 1985

CHEMICAL & ENGINEERING

NEWS

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Outlook mixed for carbon
black and titanium dioxide
A Key Chemicals Review Page 13

**Foreign investment
shows new strength
in U.S. chemicals**

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News of the Week

■ **Union Carbide consolidates business segments in move to streamline management, asks for dismissal of Bhopal-related suits filed in New York.** Page 6

■ **Two labor groups dispute Union Carbide's explanation of the Bhopal disaster.** Page 7

■ **Three candidates are nominated by petition to run in ACS's fall election.** Page 7

■ **Last-minute efforts to save the Great Plains coal gasification plant fail.** Page 8

■ **"Long-shots" in engineering research get a boost from new NSF funding approach.** Page 8

Cover: Interox America's newly expanded hydrogen peroxide plant in Deer Park, Tex.

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Business

Demand for major pigments carbon black and titanium dioxide will grow slowly worldwide; U.S. outlook is mixed. Page 13

Government

House has moved on most agency R&D budgets for fiscal 1986, increasing some and cutting others. Page 17

Science

New chiral boranes developed that could usher in a third generation of asymmetric organic synthesis. Page 22

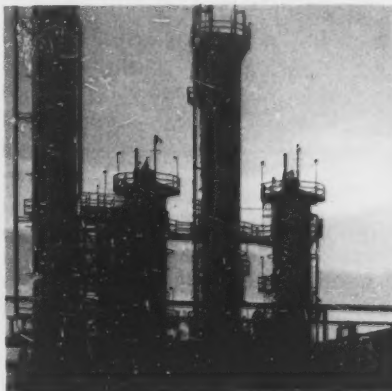
Method for determining bond lengths in solids that lack long-range order devised by researchers. Page 23

Administration's Star Wars concept draws heavy criticism in study by American Academy of Arts & Sciences. Page 26

Program to license more engineers in U.S. launched by National Council of Engineering Examiners. Page 28

ACS News

Two petitions are up for council action at the Chicago meeting: one on subscription prices, one on divisional councilors. Page 32



News Focus

Investment in U.S. chemical companies by foreign firms is increasing again, with some large and costly acquisitions in past few months. Page 9

Major Pigments Gain Global Commodity Status

Though worldwide demand for carbon black and titanium dioxide will grow slowly, U.S. outlook is mixed, with carbon black use to continue decline

Bruce F. Greek, C&EN Houston

Carbon black and titanium dioxide are becoming worldwide commodities as their international trade grows in a fashion similar to many other chemicals. In the future, U.S. producers will be facing greater competition from imports while exporting less. Prices of these two commodities are high enough to make shipping as a percentage of total cost relatively low, permitting this trade.

These changes to the worldwide demand and supply situation are causing U.S. producers to buy or build plants outside the U.S. Producers, as a result, are sometimes able to make their product abroad at lower cost than in the U.S., and they are able to sell more profitably in and outside the U.S., compared to their U.S. operations. Factors other than actual production costs, such as the strength of the dollar, can be very important in profitability.

Worldwide consumption of both of these materials, for the longer term, will tend to grow slowly. Of the two, carbon black may have the lower growth rate over the next five years at about 1% annually. The growth rate for titanium dioxide, however, will not be much higher, at 1.5% annually, according to some industry sources.

In the U.S., growth in consumption for carbon black has been forecast to be lower than worldwide

growth because demand for tires and nontire automotive elastomeric products could continue a decline that began last year. Toward the end of this decade, the decline in demand for carbon black likely will slow and then reverse to slow growth. Imports of carbon black probably will continue to increase and fill a growing part of the U.S. consumption. As a result, U.S. production of carbon black could go

smaller total volume and higher imports than does carbon black. Like carbon black going to tires, titanium dioxide will continue to have a single and very slowly growing major use—that of surface coatings. As a result, it will have a low growth in consumption. In other parts of the world, especially in developing countries, demand for paints will grow much more rapidly than in the U.S. In these countries, demand for titanium dioxide could grow at rates of 2 to 5% annually.

Titanium dioxide's growth rate is small, but higher than that for carbon black. Thus this rate likely will result in full utilization of world capacity sooner than will carbon black's. Ores from which titanium dioxide is made are available in many places of the world. Thus, new plants are likely to be built in various countries outside the U.S.

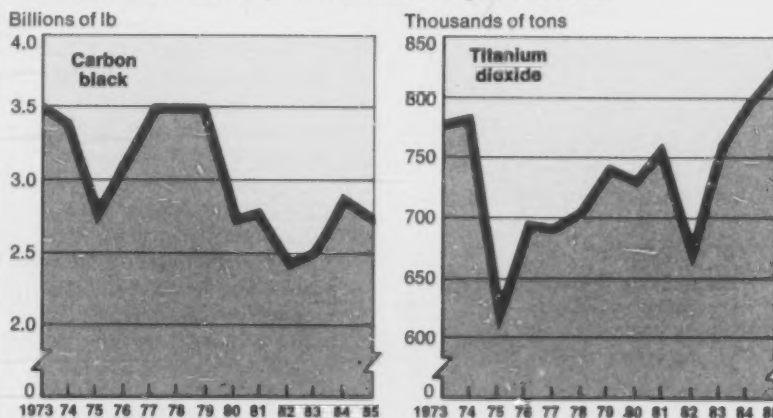
For details of the near-term outlook for carbon black and titanium dioxide, please see the following pages.

Key Chemicals

on hold after ending the decline that is now under way. Therefore, a return to production levels in the 3.5 billion lb-per-year range of the 1970s now seems to be unlikely. Major capacity expansions would be needed, and these can't be justified economically at present levels of profitability.

The outlook for titanium dioxide is somewhat similar but involves

Carbon black output remains below previous highs as titanium dioxide output exceeds 10-year record



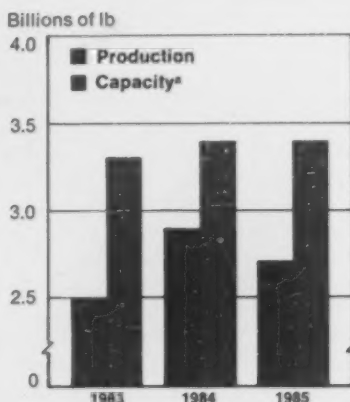
Sources: Department of Commerce, industry and C&EN estimates

Carbon black

C

- Demand slowing
- Capacity declining
- Prices may drop

PRODUCTION/CAPACITY



a First quarter.

MAJOR PRODUCERS

Ashland Chemicals, Cabot, Columbian Chemicals, J. M. Huber, Phillips Petroleum

HOW MADE

Partial oxidation of heavy petroleum fractions

MAJOR END USES (U.S.)

Tires 65%, other fabricated rubber products 25%, colorant and filler for plastics, inks, etc. 10%

FOREIGN TRADE

Exports—small, may reach 75 million lb in 1985, imports—rising, may exceed 150 million lb in 1985

PRICES

Range from 29 to 39 cents per lb, depending on grade

Production of carbon black has slowed this year after staging a two-year recovery from the recession. Output in 1985 could total 2.7 billion lb, down about 7% from 1984 production of just less than 2.9 billion lb. Even so, this decline would leave production ahead of the 2.5 billion lb in 1983.

The pigment's lag in production began in the first quarter of 1985 and accelerated in the second quarter. Predominant among the causes is the well-known increasing life-span of passenger car and light truck tires. This trend, which reduces demand for carbon black, is expected by many in the rubber and tire industries to continue in the next several years.

Capacity to make carbon black has declined this year. At the beginning of the second quarter, about 100 million lb of capacity located near Conroe, Tex., was shut down by Columbian Chemicals. An additional 150 million lb per year is on stand-by. The small expansions expected this year will add only 25 million to 50 million lb to the nameplate capacity total.

The net in-place capacity at the beginning of this year totaled a bit more than 3.4 billion lb. At the beginning of 1986, this capacity will have declined to 3.3 billion lb, with stand-by capacity almost unchanged. At that time, the operating capacity is expected to be about 3.2 billion lb.

Throughout 1985, nameplate capacity will average 3.3 billion lb, with operating capacity about 3.15 billion lb. If production does reach 2.7 billion lb, the operating rate will be 82% of nameplate capacity and 86% of effective capacity. These rates, although not as high as in some years of the 1970s, are well above recession levels.

In view of this operating rate, carbon black producers likely can't do much to increase their profits, especially with rising imports. Actual prices for carbon black could decline if crude oil prices decline. Consumers of carbon black are similar to consumers of all other products made from petrole-

um in that they expect raw material cost reductions to be passed on to them immediately if not before the cost declines.

Producers also face a short-term decline in demand for carbon black because of a decline in the production of tires, caused by the lower sales of replacement tires as tire life is increased. Another decline in the amount of rubber sold in tires for new cars has largely ended with the nearly complete use of the small-size spare tires or inflatable spare tires. The drop in replacement tire demand results from consumer willingness to buy better tires—particularly radial tires, which have much greater tread life. In addition, a trend toward better care of tires and the higher inflation pressures are helping extend tread life.

Other uses of rubber in cars and trucks also are showing little growth. The reasons are similar to those that are causing lower use of rubber in tires—smaller sized vehicles, which reduces the amount of weather stripping and gasketing per unit. Some competition from plastics may be reducing rubber demand slightly, but most of the market capture by plastics is over.

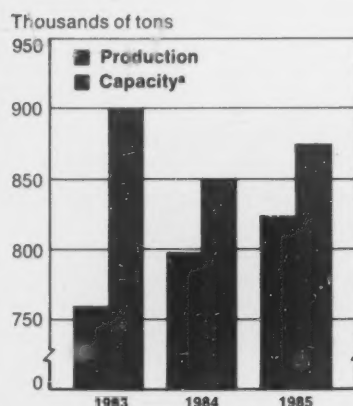
Nonautomotive uses of rubber and carbon black are relatively small. Their prospects are diverse. Use in industrial belting and hoses depends directly on heavy industrial operations, which generally seem to be experiencing little if any growth. One application is growing rapidly from a small base: that of single-ply roofing made of ethylene-propylene-diene rubber. This product continues to be improved and to be demonstrated as more cost effective than are other kinds of roofing.

A number of other uses of carbon black, such as in inks, paints, and plastics, all are small and are growing at low rates. None will significantly affect the total demand for carbon black, which leaves the developing roofing application as the best prospect to offset the declines in demand for automotive uses of the product.

Titanium dioxide

- **Demand strong**
- **Capacity growing**
- **Prices firm**

PRODUCTION/CAPACITY



a First quarter.

MAJOR PRODUCERS

Du Pont, Kemira Oy, Kerr-McGee, SCM

HOW MADE

Recovery from natural or synthetic ores using chlorine, carbon (coke), and oxygen, or sulfuric acid

MAJOR END USES

Surface coatings 50%, paper coatings 25%, plastics colorant 15%

FOREIGN TRADE

Exports—to hold at about 175,000 tons in 1985, imports—to decline to about 180,000 tons in 1985

PRICES

70 cents per lb for anatase grade, and 75 cents per lb for rutile grade

Titanium dioxide, often considered to be a mature product, has several active developments under way. Production is pressing capacity. U.S. demand well exceeds production, but imports making up the difference may decline in 1985, possibly causing further tightening of supplies. Furthermore, a change in ownership of some U.S. capacity has occurred recently.

Production of titanium dioxide in 1985 will total 825,000 tons. The period of greatest strain on capacity is almost over for this year, after which a better estimate of the potential production for the year can be made. Seasonality of production always causes difficulties in estimating annual production early in the year.

Traditionally, the greatest demand for titanium dioxide occurs during the second and third quarters. Producers generally have to draw upon inventories to meet demands, which may be greater than production capability. Then during the fourth and first quarters of a year, they rebuild inventories. To some degree, output in 1985 will depend on the willingness of producers and consumers to carry inventory through the next winter in anticipation of demands expected next spring and summer.

Demand for titanium dioxide in the U.S. will surpass 900,000 tons in 1985. Besides actual production, this demand will be met because imports will exceed exports and because there will be possibly some decline in inventories. Imports, however, are forecast to be lower than in 1984, accounting for some of the tightness of supply. Most titanium dioxide imports come from Europe where there is surplus capacity. The economic recovery in Europe is allowing producers there to increase sales to local markets, which reduces the quantity available for export. Exports from the U.S. aren't expected to change much, mainly because no more supplies will be available for export.

The list of titanium dioxide producers continues to change. This year American Cyanamid opted to sell its

business to a Finnish company, Kemira Oy, which will continue production.

Such changes in ownership and in plant operation have, over the years, altered capacity as well. Following shut-down of some old capacity that used technology involving reactions with sulfuric acid—which leads to much higher costs to control pollution—total capacity has been growing. Du Pont has completed a new titanium dioxide plant at De Lise, Miss.—the only new one built in some years. However, capacity additions have been mainly through debottlenecking expansions. This year, for example, Kerr-McGee is adding more than 8000 tons of annual capacity to its plant at Hamilton, Miss., with startup expected in early 1986.

The nameplate total of in-place operating capacity at the beginning of 1985 was 875,000 tons, possibly a bit more. If production in 1985 reaches 825,000 tons, then plants will have an average operating rate of almost 95% for the year. This high level of operation indicates that some advances in process techniques and additional debottlenecking have occurred.

Strong demand for titanium dioxide in all of its major uses is behind the full operation of plants and the lingering tightness in supply. About half of U.S. consumption is in surface coatings, with architectural coatings (mainly exterior and interior residential paints) accounting for nearly two thirds of this share. Another quarter of surface coating use goes for original equipment manufacture, largely for items such as appliances, machinery, transportation equipment, and metal furniture and fixtures.

The other major applications of titanium dioxide are in paper coatings and in plastics. Both of these uses have grown faster than has the demand for use in surface coatings, but their base is smaller. Longer-term, these uses, and some of the small miscellaneous ones such as in ceramics, will account for most of the increase in demand for titanium dioxide.

Congress Finally Moves on Fiscal 1986 Money Bills

By adjournment, House had approved spending levels for most major research funding agencies, deviating frequently from Administration requests

Janice R. Long, C&EN Washington

The House didn't set any efficiency record this year in moving fiscal 1986 money bills. In the past two years, it completed action on 11 of the 13 regular appropriation bills by the middle of June. This year it was the middle of July before any of them came up for a floor vote.

The holdup was caused by Congress' inability to agree on a first budget resolution. More than a decade ago, Congress set up a formal budget process that called for adoption by May 15 of a so-called first budget resolution setting a target limit on federal spending and priorities for the way those funds would be spent. To make sure that the limits would have real meaning, Section 302(a) of the Congressional Budget Act says that spending legislation—appropriation bills—cannot be considered until Congress has agreed on the budget resolution.

That process worked fairly well until this year. However, when a budget resolution was not forthcoming by July 24, the House, on a party line vote, decided to suspend Section 302(a) of the budget act. That broke the logjam, and the appropriations bills moved swiftly. By the time it adjourned for its annual August vacation, the House had approved fiscal 1986 spending levels for all but two of the major research funding agencies—the Department of Defense and the National Institutes of Health.

As usual, the House set its own budget priorities, adding funds above the Administration request for some programs and subtracting funds from other ones. Even when the totals come close to being the same, the budget items the House emphasized quite often aren't the same as those the Administration emphasized.

One good example of this tinker-

ing can be found in the Department of Energy's R&D budget, which was part of the first House-passed appropriation bill. The House allowed a total of \$4.2 billion, 1% less than DOE has available this year but 1% more than the Administration requested. However, the Administration wanted an 18% increase in DOE's weapons R&D budget. It got a 4% increase. It wanted to cut

House boosts a few R&D budgets, cuts others

\$ Millions	1986		1985	% change 1985-86
	Appropriation	Request		
NASA	\$ 7,666.0	\$ 7,886.0	\$ 7,491.4	2%
Space flight control and data communications	3,402.9	3,509.9	3,601.8	-6
R&D	2,756.8	2,881.8	2,422.6	14
Management activities	1,367.0	1,345.0	1,317.0	4
Facilities	139.3	149.3	150.0	-8
Energy	4,181.9	4,153.9	4,226.3	-1
Energy supply R&D	1,939.6	1,955.4	2,018.2	-4
Nuclear	607.6	657.6	623.0	-3
Supporting research and technical analysis	514.0	480.8	477.8	7
Magnetic fusion	385.0	390.0	437.0	-12
Environment	229.7	227.7	230.5	—
Solar	147.0	148.0	178.0	-17
Electric energy systems and storage	30.1	26.1	40.1	-25
Geothermal	26.2	25.2	31.8	-18
Weapons R&D	1,072.4	1,211.6	1,027.3	4
General science and research	685.5	685.4	730.0	-6
Fossil R&D	299.5	160.5	274.9	9
Conservation R&D	184.9	141.0	175.2	5
NSF	1,522.9	1,568.4	1,499.0	1
Research and related activities	1,347.2	1,397.7	1,301.9	3
Antarctic programs	115.1	120.1	110.1	4
Science education activities	60.6	50.6	87.0	-30
EPA	1,491.2	1,362.6	1,309.8	14
Salaries and expenses ^a	690.2	654.7	656.3	5
Abatement, control, and compliance	577.6	495.5	460.5	25
R&D	223.4	212.4	193.0	16
Commerce	1,329.9	1,139.0	1,337.3	-1
NOAA	1,121.2	934.3	1,113.1	1
NBS	124.0	120.0	124.0	—
PTO	84.7	84.7	100.2	-16
USDA	905.5	849.8	912.4	-1
Agricultural Research Service	492.8	483.3	494.1	—
Cooperative State Research Service	276.4	251.2	285.8	-4
Forest Service Research	125.0	104.2	121.0	3
National Agricultural Library	11.3	11.1	11.5	-2
FDA	419.7	409.1	414.8	1
TOTAL	\$17,517.1	\$17,368.8	\$17,191.0	2%

^a Includes in-house research funding.

the fossil R&D budget 42%, the House opted for a 9% raise. And the House added a new category to the DOE budget—the clean coal technology reserve—funded by a three-year \$750 million transfer from the embattled Synthetic Fuels Corp. Projects financed by the reserve are to be cost-shared by industry.

The House also approved a 7% increase for supporting research and technical analysis, instead of the requested 1% increase. Among the additions in that budget category was \$2 million added to the \$94.2 million budget request for chemical sciences to support increased activities in the fundamental chemistry of energy processes at Argonne National Laboratory. The House also added \$14 million to the \$183 million materials science budget request, including \$12 million for completion of the National Center for Chemical Research at Catholic University, \$6 million to support establishment of a Center for Science & Technology at Atlanta University, and \$5 million to support a competition for development of proposals for a 6-GeV synchrotron light source. However, the House cut \$8 million from the \$17.4 million requested for the Lawrence Berkeley Center for Advanced Materials Research.

Next up for a floor vote was the appropriation bill that includes the Commerce Department. The House flatly rejected the Administration-proposed 15% decrease in funding for the National Oceanic & Atmospheric Administration's operation, research, and facilities budget, and instead approved an essentially level budget of \$1.1 billion. That allows for salvage of the sea grant program, coastal zone management grants, and the Great Lakes Environmental Research Laboratory and the National Underseas Research program, all of which were slated for termination. The House held the National Bureau of Standards budget level at \$124 million, once again saving the Center for Fire Research and the Center for Building Technology, but disallowing the \$8 million requested for construction of a cold neutron research facility. The House did go along with the Administration's plan to cut the Pat-

ent & Trademark Office budget 16% to \$84.7 million. The decrease is supposed to be offset by increased processing fees that Congress has yet to approve.

The House-approved funding level for the National Science Foundation is \$1.5 billion, 3% less than the budget request and a scant 1% above current funding levels. On paper the research and related activities budget gets a 3%, rather than the requested 7%, increase to \$1.3 billion. The House directed that the reduction be applied to capital improvement projects such as the Cornell Electron Storage Ring, the Wisconsin Synchrotron Center, and the Very Long Baseline Array. It notes that relief from the hard freeze on NSF's budget called for in the budget resolution was possible because of a deferral of \$31.4 million in the fiscal 1985 science education budget, funds which can be applied to research and related activities in fiscal 1986. Meanwhile, the science education budget is \$60.6 million, 20% more than the budget request.

The National Aeronautics & Space Administration's budget is set at \$7.7 billion, 2% over current levels but 3% less than requested. However, NASA's R&D budget is up 14% to \$2.8 billion. That includes \$200 million for the space station, \$129 million for an upper atmospheric research satellite, \$128 million for the space telescope, and \$87.3 million for the gamma ray observatory.

The Environmental Protection Agency's extramural R&D budget is up 16% to \$223 million, 5% more than requested. The House added \$5 million to the request for grants and centers to maintain exploratory research at the current level, \$4 million for hazardous waste and groundwater research, \$3 million for total exposure assessment studies of toxic pollutants, and \$2.5 million for indoor air pollution research. However, it deleted \$10 million from the request for acid rain research, because as the Appropriations Committee put it, "The 60% increase proposed in the 1986 acid rain program is excessive—and a poor excuse for inaction on acid rain controls."

The Department of Agriculture's research programs did not fare as well as EPA's and NASA's; in ag-

gregate they are down 1% to \$906 million. But then the Administration wanted to cut them 7%. Funding for the Agricultural Research Service is set at \$493 million, including \$200,000 for continued assessment of dioxin contamination in the Great Lakes food chain, \$500,000 for establishment of a catfish breeding, genetics, and endocrinology program at the Delta States Research Center, and \$1.1 million for plant stress and water conservation research at Texas Tech University. The Cooperative State Research Service gets \$276 million, including \$34 million for competitive research grants. Of that amount, which is 25% below current-year funding, \$20 million is earmarked for biotechnology, \$16.5 million for plant science, \$4.5 million for animal science, and \$3 million for pest science.

The House once again refused to go along with a significant cut back in Forest Service research programs, approving a 3% increase to \$125 million rather than the proposed 14% cut. That amount includes \$12 million for acid rain research, with \$5 million going for terrestrial effects research; \$4 million for the competitive grants research program; and almost \$2 million for research on insects and disease.

The Food & Drug Administration's budget, which for some reason is included in the Agriculture appropriation bill, is set at \$420 million, 3% more than requested and 1% more than is available this year. A floor amendment provided \$2 million to develop and improve screening tests for Acquired Immune Deficiency Syndrome and to review and approve new diagnostic and treatment products. The AIDS money is part of \$37 million in additional funding that the Administration is requesting in fiscal 1986 for research on the disease. The remainder of the funding will be included in the Labor-Health & Human Services appropriation bill.

Of course the House does not have the last say in setting agency budgets. The Senate, which in recent years has been slightly more generous where research programs are concerned, is still to be heard from. □

Chemical earnings continue
to drop in second quarter
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CHEMICAL & ENGINEERING

NEWS



SUPERCOMPUTERS

More power comes
to theoretical chemists

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BETHESDA MD 20814

News of the Week

■ District court judge orders EPA to require cuts in SO₂ emissions from electric utilities within nine months. **Page 4**

■ U.S. water quality is much improved since 1977, when first water pollution control law was enacted. **Page 5**

■ Instrument that simultaneously measures magnetic character of a surface and its physical structure down to 10-nm dimensions developed at NBS. **Page 5**

■ U.S. Customs rules that all imported fuel-grade ethanol must be subject to 60 cent-per-gal duty. **Page 5**

■ First of Intel's IPSC line of high-power, low-cost computers go to Yale and ORNL. **Page 6**

■ Human gene that codes for blood cell protein cloned by Cetus scientists. **Page 6**

Cover: Molecular modeling by Cray X-MP supercomputer shows sodium ion (green) surrounded by water molecules (orange) traveling down the acetylcholine receptor ion channel (blue) in nerve tissue. Photo copyright: Regents, University of California

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Business

U.S. chemical company earnings continue to drop in the second quarter, mainly because of soft prices, foreign competition. **Page 18**

International Business

Canadian chemical firms' sales and earnings both slipped in first-half 1985, but execs see improvement in second half. **Page 24**

Government

Detailed assessment of effects of tax policies on high-technology industries provided by Congressional Budget Office report. **Page 26**

The U.S.S.R.'s declared moratorium on nuclear testing raises some fundamental test ban issues. **Page 27**

Proposed legislation to help modernize research laboratories at colleges and universities aired at subcommittee hearing. **Page 28**

Technology

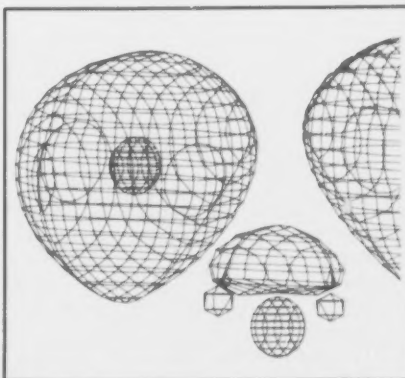
System that monitors air concentrations of different chemicals at in-plant locations developed by IBM, Perkin-Elmer. **Page 30**

Science

Binuclear platinum(II) complex can be used as a photocatalyst, because of its relatively long-lived phosphorescence. **Page 32**

Books

"The Plutonium Business and the Spread of the Bomb" by Walter Patterson airs fears of nuclear proliferation. **Page 33**



News Focus

Supercomputers, which can solve big problems in a small amount of time, are found in more U.S. computer centers than ever before. **Page 7**

Chemical Earnings Continue To Decline in Second Quarter

William J. Storck, C&EN New York

Problems continued unabated for the chemical industry in the second quarter this year. Sales and earnings both fell for U.S. chemical companies as well as oil and gas producers with chemical operations, and earnings were off for diversified firms producing chemicals.

Though production increased in the second quarter, chemical makers were still having problems with pricing, essentially because of pressures from two fronts. The first was competition from imported prod-

ucts, a factor that has held prices in check for some time. The strength of the dollar against other currencies has in effect given a subsidy to foreign producers, allowing them to sell their products here at prices that are highly competitive with U.S.-produced chemicals and to take overseas markets away from U.S. chemical producers.

The second factor is softness in oil prices. This has led chemical customers to resist price increases attempted by producers. Customers claim that producers should pass along any savings to them. This ig-

nores, of course, other factors in the price structure of chemicals.

The result has been lower demand than should be normal at this time in the business cycle and consequent overcapacity in the industry. Thus, profit margins for chemicals have been shrinking even though chemical companies have trimmed production costs in the past five years. Many of the cost-cutting measures seem to have been exploited to their limits and unless another round is instituted, chemical companies now will have to rely on traditional marketplace methods to increase mar-

Chemical industry leaders for the second quarter . . .

Sales			Earnings ^a			Profitability		
Rank	\$ Millions	Rank 1984	\$ Millions	Rank 1984		Earnings as % of sales	Rank 1984	
1 Dow Chemical	\$3002.0	1	Dow Chemical	\$155.0	1	International Flavors	14.8%	2
2 Union Carbide	2258.0	2	Monsanto	124.0	2	Loctite	13.1	1
3 W. R. Grace	1908.9	4	PPG Industries	89.4	4	Nalco Chemical	11.3	4
4 Monsanto	1627.0	3	Union Carbide	85.0	3	Freeport-McMoRan	10.8	3
5 PPG Industries	1100.0	5	Celanese	45.0	9	Ethyl	8.9	13
6 American Cyanamid	911.1	6	W. R. Grace	41.4	5	Petrolite	8.6	9
7 Chesebrough-Pond's	825.9	nr	Rohm & Haas	41.4	7	Air Products	8.2	8
8 Celanese	780.0	7	Air Products	37.7	10	PPG Industries	8.1	12
9 Hercules	698.8	8	Ethyl	36.0	11	First Mississippi	7.8	5
10 Rohm & Haas	553.6	9	Hercules	33.9	6	Monsanto	7.6	11

. . . and for the first six months of 1985

Sales			Earnings ^a			Profitability		
Rank	\$ Millions	Rank 1984	\$ Millions	Rank 1984		Earnings as % of sales	Rank 1984	
1 Dow Chemical	\$5755.0	1	Dow Chemical	\$265.0	2	International Flavors	14.7%	1
2 Union Carbide	4430.0	2	Monsanto	211.0	1	Freeport-McMoRan	11.4	2
3 W. R. Grace	3488.8	4	PPG Industries	169.8	4	Nalco Chemical	11.0	4
4 Monsanto	3251.0	3	Union Carbide	156.0	3	Petrolite	8.8	8
5 PPG Industries	2200.0	5	Rohm & Haas	81.7	5	Ethyl	8.2	14
6 American Cyanamid	1793.8	6	Celanese	81.0	9	Air Products	8.0	10
7 Celanese	1528.0	7	W. R. Grace	76.9	7	Loctite	7.8	3
8 Hercules	1337.0	8	American Cyanamid	74.9	6	PPG Industries	7.7	12
9 Chesebrough-Pond's	1264.0	nr	Air Products	73.3	10	Lubrizol	7.4	7
10 Rohm & Haas	1106.4	10	Hercules	69.7	8	Rohm & Haas	7.4	5

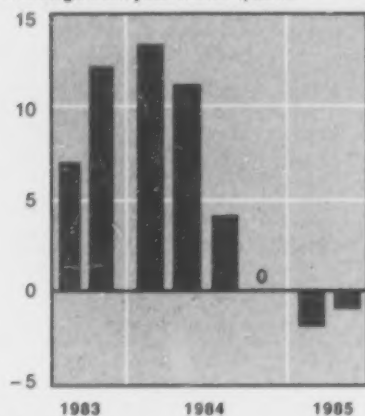
^a After taxes. nr = not ranked. Note: Based on 30 companies listed on page 20.

Chemical industry 1985 second-quarter results

- Sales slip 1%
- Earnings fall 17%
- Profit margins up to 5.2%
- Production rises 4.5%
- Prices remain level

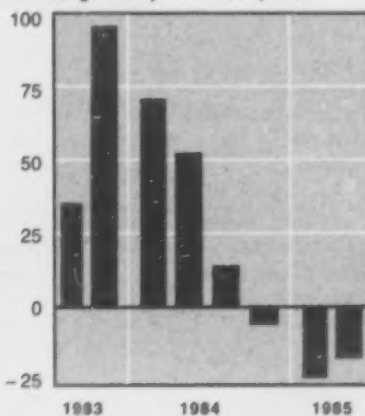
Sales

% change from year-earlier quarter



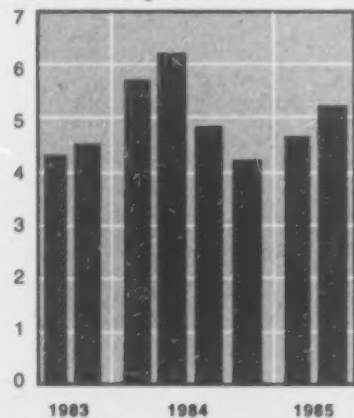
Earnings

% change from year-earlier quarter



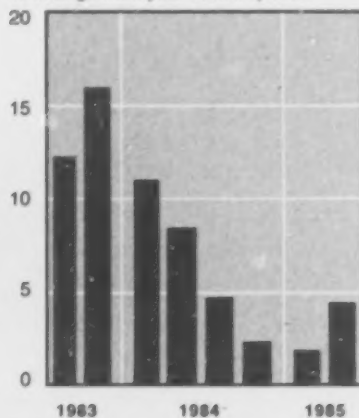
Profit margins

After-tax earnings as % of sales



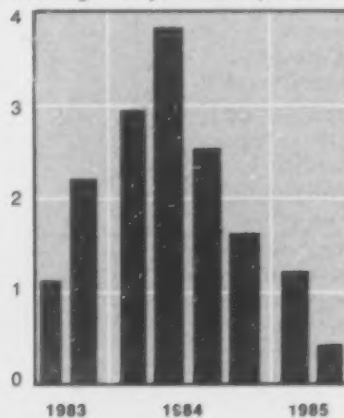
Production

% change from year-earlier quarter



Prices

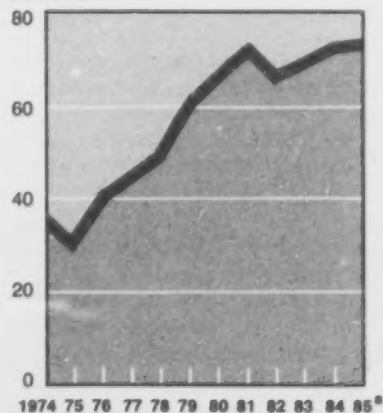
% change from year-earlier quarter



Sales in 1985 will rise about 2% and earnings will be about the same as last year, lowering profit margins to 5.1%

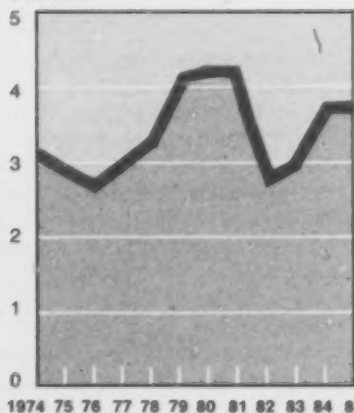
Annual sales

\$ Billions



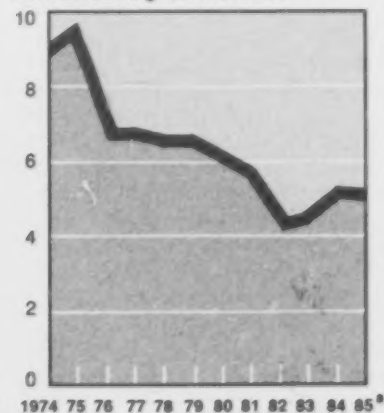
Annual earnings

\$ Billions



Annual profit margins

After-tax earnings as % of sales



■ CAEN estimates. Note: All sales, earnings, and profit-margin data are based on combined results of the 30 companies listed on page 20.

Chemical earnings slid 17% in the second quarter

	SECOND-QUARTER 1985						FIRST-HALF 1985			
	Sales	Earnings ^a	Change from 1984		Profit margin ^b		Sales	Earnings ^a	Change from 1984	
	(\$ millions)		Sales	Earnings	1985	1984	(\$ millions)		Sales	Earnings ^a
Air Products ^c	\$ 460.0	\$ 37.7	2%	-1%	8.2%	8.5%	\$ 917.7	\$ 73.3	2%	-2%
American Cyanamid ^c	911.1	32.3	0	-38	3.5	5.7	1,793.8	74.9	-1	-28
Celanese ^c	780.0	45.0	-9	-4	5.8	5.5	1,528.0	81.0	-10	-11
Chemad	92.8	4.3	8	-29	4.7	7.1	181.6	8.3	9	25
Chesebrough-Pond's ^{c,d}	825.9	23.9	nm	nm	2.9	5.1	1,264.0	38.7	nm	nm
Crompton & Knowles	61.6	2.3	-1	-3	3.7	3.8	117.4	3.5	-4	-16
Dow Chemical ^c	3,002.0	155.0	1	-10	5.2	5.8	5,755.0	265.0	-2	-13
Essex Chemical	58.8	3.5	11	-5	6.0	7.0	104.3	5.9	13	3
Ethyl	404.3	36.0	-9	14	8.9	7.1	781.7	64.2	-10	14
First Mississippi	74.8	5.8	-13	-31	7.8	9.8	143.0	9.7	-9	-26
Freeport-McMoRan	190.9	20.6	-12	-20	10.8	11.9	405.6	46.3	-4	-3
H. B. Fuller	115.7	3.5	-1	-13	3.0	3.4	224.3	5.2	1	-14
W. R. Grace ^c	1,906.9	41.4	10	-28	2.2	3.3	3,488.8	76.9	8	-26
Hercules ^c	698.8	33.9	5	-37	4.9	8.1	1,337.0	69.7	4	-31
International Flavors	129.8	19.2	-1	-9	14.8	16.2	251.1	36.8	-1	-8
International Minerals ^c	465.6	17.1	-1	-32	3.7	5.4	878.9	47.8	3	-8
Loctite	59.9	7.8	-6	-36	13.1	19.2	113.9	8.9	-10	-37
Lubrizol	247.4	17.8	11	-18	7.2	9.7	500.4	37.2	16	-3
Monsanto ^c	1,627.0	124.0	-10	-14	7.6	8.1	3,251.0	211.0	-8	-34
Morton-Thiokol ^c	450.7	28.0	1	7	6.2	5.9	947.6	60.0	2	17
Nalco Chemical	166.2	18.8	-2	-4	11.3	11.5	330.3	36.4	-2	-1
National Distillers ^c	508.2	4.0	-6	-70	0.8	2.5	1,082.4	24.5	-4	-52
Olin ^c	462.4	13.7	-4	-54	3.0	6.2	937.5	25.9	0	-51
Pennwalt	275.2	12.8	1	11	4.6	4.2	536.7	19.5	1	-7
Petrolite	76.8	6.6	9	10	8.6	8.5	154.4	13.6	8	14
PPG Industries ^c	1,100.0	89.4	0	4	8.1	7.8	2,200.0	169.8	5	6
Reichhold Chemicals	235.2	2.1	7	-74	0.9	3.6	420.3	4.5	-2	-67
Rohm & Haas ^c	553.6	41.4	0	-20	7.5	9.4	1,106.4	81.7	0	-24
Union Carbide ^c	2,258.0	85.0	-6	-26	3.8	4.8	4,430.0	156.0	-8	-30
Witco Chemical	369.5	14.7	-3	-9	4.0	4.2	734.6	25.7	-2	-17
Total 14 largest companies ^e	\$15,186.3	\$748.0	-1%	-18%	4.9%	5.9%	\$29,654.1	\$1417.5	-2%	-21%
Second 15 companies	\$ 2,559.1	\$175.8	-2%	-11%	6.9%	7.6%	\$ 4,999.4	\$ 325.8	-1%	-7%
GRAND TOTAL ^e	\$17,745.4	\$923.8	-1%	-17%	5.2%	6.2%	\$34,653.5	\$1743.3	-2%	-19%

a After-tax earnings from continuing operations excluding significant extraordinary and nonrecurring items. b Earnings as a percentage of sales. c One of 15 largest companies. d Since Chesebrough's results were not restated for prior years as a result of acquisition of Stauffer, year-to-year comparisons are meaningless. e Excludes results of Chesebrough. nm = not meaningful.

gins. And it is these traditional methods that just don't seem to be working.

As a result, of 29 of the 30 largest U.S. chemical firms regularly surveyed by C&EN, just five—Ethyl, Morton-Thiokol, Pennwalt, Petrolite, and PPG Industries—registered increases in earnings from continuing operations in the second quarter compared with the same period in 1984. (Chesebrough-Pond's is not included in any of the cumulative totals. It has not restated its results prior to the acquisition of Stauffer Chemical, rendering any year-to-year comparisons meaningless.)

Only six of the companies surveyed recorded increases in profit margins—the same five companies

Ground rules for C&EN earnings analysis

C&EN's quarterly report on financial performance of the U.S. chemical industry contains data from the 30 largest U.S. basic chemical companies and from 41 oil and diversified companies, each with more than \$200 million in annual chemical sales.

To be included in the table of basic chemical producers, a company must have at least 40% of its sales in chemicals, and its chemical operations must be the largest single portion of the company's operations. That is why Du Pont, for example, is included in the table of diversified manufacturers.

In referring to chemical sales, C&EN means those chemicals whose molecular composition has been changed in the course of manufacture. Hence, chemical sales include those of traditional categories of basic petrochemicals and inorganics, organic intermediates and inorganic compounds, polymers such as plastics and fibers, agricultural chemicals, and specialty derivatives.

In listing earnings, the survey gives after-tax income for continuing operations before nonrecurring items and extraordinary charges. Foreign currency translations are included.

FIRST-HALF 1985

12-MONTH RUNNING DATA

Profit margin ^b		Change from 1984		Profit margin	
1985	1984	Sales	Earnings	1985	1984
8.0%	8.3%	2%	-1%	7.7%	8.0%
4.2	5.9	1	-19	4.5	5.6
5.3	5.4	-6	-14	4.8	5.2
4.6	5.6	15	-13	4.8	6.4
3.1	4.1	nm	nm	nm	nm
3.0	3.4	-5	1	3.2	3.0
4.6	5.2	-3	-8	3.9	4.1
5.7	6.2	4	64	5.6	3.6
8.2	6.5	-10	16	8.7	6.7
6.8	8.4	1	15	6.7	5.9
11.4	11.4	1	-2	11.5	12.0
2.3	2.7	2	-12	2.7	3.2
2.2	3.2	7	-26	1.9	2.7
5.2	7.9	1	-8	6.6	7.2
14.7	15.7	1	-4	14.0	14.8
5.4	6.1	6	-10	5.6	6.6
7.8	11.2	-4	-10	10.3	10.9
7.4	8.9	9	-1	7.2	8.0
6.5	9.1	-5	-34	5.1	7.4
6.3	5.5	6	12	6.7	6.3
11.0	11.0	-4	-3	10.6	10.5
2.3	4.5	-16	-43	2.1	3.1
2.8	5.6	-2	-32	2.9	4.2
3.6	4.0	3	-8	4.6	5.2
8.8	8.4	6	24	9.0	7.7
7.7	7.6	5	6	7.5	7.4
1.1	3.1	-1	-31	2.1	3.0
7.4	9.8	3	-16	7.1	8.7
3.5	4.6	-3	-22	3.2	4.0
3.5	4.1	1	-6	3.8	4.1
4.8%	6.0%	-1%	-16%	4.4%	5.2%
6.5%	7.0%	0%	0%	6.9%	6.8%
5.0%	6.1%	-1%	-13%	4.8%	5.4%

that had profit increases, plus Celanese, whose revenues fell faster than did earnings.

For the 29 companies for which year-to-year comparisons can be made, sales totaled more than \$17.7 billion, a decline of 1% from the second quarter last year. Earnings at the 29 companies fell 17% from a year ago to a total of \$924 million. Though this is less than the 2% decline in sales and 24% drop in earnings registered in the first quarter, it is still indicative of an industry plagued by some fundamental problems. Profit margins in the second quarter averaged 5.2%, a drop of a full percentage point from last year's second-quarter average profit margin of 6.2%.

As in the past, economic realities hit the larger chemical companies—traditionally more weighted toward basic, commodity chemicals—harder than they did the smaller firms in the survey. For the 14 largest companies on the list, sales slipped 1% to a total of almost \$15.2 billion and earnings fell 18% to \$748 million. Sales of the 15 smaller companies declined 2% to a total of \$2.56 billion, and earnings dropped 11% to \$176 million.

The 15 smaller companies also remained more profitable, with an average profit margin in the second quarter of 6.9% as compared to 4.9% for the 14 largest firms. In the second quarter of 1984, the smaller companies had an average profit margin of 7.6%; the larger companies, 5.9%.

The second quarter did not help the year much for chemical companies. In the first six months, sales of the 29 companies declined 2% to a total of almost \$34.7 billion, and earnings fell 19% to \$1.74 billion. Profit margins at the 29 firms dropped to 5.0% from 6.1% in the first six months of 1984.

This picture also holds for the larger company vs. smaller company comparison. For the 14 largest firms, sales in the first six months slipped 2% to almost \$29.7 billion; earnings were down 21% to about \$1.42 billion. For the smaller firms, sales on average declined 1% to almost \$5.0 billion and earnings fell 7% to \$326 million. Profit margins for the larger companies were 4.8%, compared with 6.5% for the smaller firms. In the six months of last year, the average profit margin for the larger companies was 6.0%; for the smaller firms, 7.0%.

For the second quarter of this year, sales rose an average of 4% from the first quarter and earnings climbed 18% for the 29 companies. For the

14 larger firms for this period, sales grew 14% and earnings increased 19%. Sales of the smaller companies increased 5%; earnings, 15%.

Chemical companies cannot find any solace in the performance of other groups of companies. Although sales at 15 oil and gas companies fell an average of 5% to a total \$98.1 billion, earnings declined just 4% in the second quarter to a total of \$4.72 billion. Sales of diversified and other companies with large chemical operations surveyed by C&EN remained about level and earnings fell 18%.

Corporate executives had little specific to blame for the lackluster performance in the second quarter and instead concentrated on the general economy and its ramifications. At Monsanto, where earnings decreased 14% on a sales drop of 10%, president and chief executive officer Richard J. Mahoney says, "Monsanto's second-quarter results reflect the continuing difficult economic environment for chemical-based industries. Since mid-1984, the U.S. manufacturing sector generally has not gotten much benefit from the modest economic growth we have encountered. Consequently, U.S. industrial demand for chemical-based products has lagged." He continues, "Many of the benefits of Monsanto's restructuring, cost controls, and efficiency improvements, which began in the 1980-82 period, have been temporarily offset in the U.S. by the dollar's strength and artificial disadvantages of currency values."

At Du Pont, the largest U.S. producer of chemicals, where earnings fell 39% on a 6% sales decline, chairman and chief executive officer Edward G. Jefferson agrees with Mahoney about the economy. He says that Du Pont's reduced earnings "reflect continued weakness in the industrial sector of the domestic economy, which has experienced virtually no growth since the middle of 1984. In addition, the abnormally strong dollar has further eroded prices and volume in domestic markets, which are flooded with imports, and in international markets where the cost competitiveness of our exports has been severely impaired."

Results varied widely at oil, diversified companies

	% chemical sales	SECOND-QUARTER 1985						FIRST-HALF 1985					
		Sales	Earnings ^a	Change from 1984		Profit margin ^b		Sales	Earnings ^a	Change from 1984		Profit margin ^b	
		(\$ millions)		Sales	Earnings	1985	1984	(\$ millions)		Sales	Earnings	1985	1984
OIL AND GAS COMPANIES													
American Petrofina	15%	\$ 587.0	\$ 12.9	18%	-18%	2.2%	3.2%	\$ 1,153.0	\$ 10.2	10%	-61%	0.9%	2.5%
Amoco	10	7,300.0	800.0	-1	15	8.2	7.1	1,073.0	14.3	-4	-5	1.3	1.3
Atlantic Richfield	10	5,771.0	402.0	-5	-12	7.0	7.5	11,538.0	775.0	-8	-14	6.7	7.1
Chevron	4	11,700.0	380.0	-6	0	3.2	3.0	24,300.0	734.0	23	-3	3.0	3.8
Diamond Shamrock	21	1,030.1	45.9	-9	-29	4.5	5.7	1,984.8	104.9	-13	-15	5.3	5.4
Exxon	7	22,970.0	1290.0	-6	-4	5.6	5.6	46,233.0	2615.0	-6	-7	5.7	5.7
Mobil	4	14,473.0	411.0	-3	12	2.8	2.4	29,814.0	731.0	-1	-2	2.5	2.5
Occidental Petroleum	7	3,678.9	137.7	-3	10	3.7	3.3	7,375.4	220.5	-4	-5	3.0	3.0
Shell Oil	17	5,102.0	337.0	-5	-19	6.6	7.8	9,845.0	633.0	-4	-15	6.4	7.2
Standard Oil (Ohio)	5	3,492.0	390.0	7	-15	11.2	14.1	6,690.0	733.0	9	-13	11.0	13.6
Sun Co.	3	3,680.0	146.0	-7	28	4.0	2.9	7,350.0	273.0	-10	7	3.7	3.1
Tenneco	7	3,782.0	164.0	-1	-25	4.4	5.8	7,481.0	227.0	-2	-39	3.0	4.9
Texaco	2	11,700.0	278.0	-10	11	2.4	1.9	23,700.0	484.0	0	-15	2.0	2.4
Unocal (Union Oil)	10	2,900.0	120.4	-3	-35	4.2	6.2	5,700.0	301.1	0	-18	5.3	6.4
Williams Cos.	22	726.5	19.8	-11	-59	2.7	6.0	1,771.1	49.0	-7	-63	2.8	6.9
DIVERSIFIED MANUFACTURERS													
Allied	23	2,753.0	152.0	0	17	5.5	4.7	5,534.0	286.0	0	9	5.2	4.8
Aluminum Co. of America	4	1,365.8	56.2	-6	-50	4.1	7.8	2,679.8	62.9	-9	-70	2.3	7.2
Borden	28	1,192.7	47.5	1	-7	4.0	4.3	2,270.1	82.3	-1	-3	3.6	3.7
Borg-Warner	21	1,032.8	49.0	0	5	4.7	4.5	1,972.1	93.6	-1	-3	4.7	4.9
Du Pont	34	8,532.0	268.0	-6	-39	3.1	4.8	16,791.0	490.0	-9	-40	2.9	4.4
Eastman Kodak	21	2,455.7	164.3	-4	-28	6.7	9.0	4,582.8	279.5	-2	-28	6.1	8.2
Engelhard	23	479.8	10.3	-21	-44	2.1	3.0	1,054.9	22.0	-16	-34	2.1	2.7
FMC	37	881.3	54.5	3	-18	6.2	7.7	1,637.1	98.5	-6	-13	6.0	6.5
GAF	51	188.1	15.4	-2	29	8.2	6.2	364.0	26.5	1	37	7.3	5.4
General Electric	7	6,840.0	500.0	3	-14	7.3	8.7	13,040.0	1011.0	-2	-5	7.8	8.0
Georgia-Pacific	10	1,794.0	67.0	7	2	3.7	4.0	3,374.0	116.0	7	6	3.4	3.5
B. F. Goodrich	40	894.4	12.5	1	-61	1.4	3.7	1,600.0	14.8	-6	-65	0.9	2.5
Kaiser Aluminum	18	845.3	-14.3	6	def	def	3.7	1,661.9	-32.8	11	def	def	3.2
Koppers	45	486.2	-12.0	5	def	def	3.2	839.9	-25.0	4	def	def	1.4
Eli Lilly	23	756.8	110.1	5	5	14.5	14.5	1,665.7	271.0	3	8	16.3	15.6
3M	15	1,954.0	168.0	0	-13	8.6	9.9	3,860.0	332.0	1	-10	8.6	9.6
Merck	17	877.4	137.9	-2	5	15.7	14.7	1,733.7	269.5	0	5	15.5	14.7
NL Industries	39	358.1	6.9	3	73	1.9	1.1	685.5	11.3	3	134	1.6	0.7
Northwest Industries	0	295.3	-50.9	-8	def	def	6.7	554.7	-42.7	-11	def	def	5.9
Pfizer	10	1,001.9	137.5	1	16	13.7	12.0	1,953.8	284.9	2	15	14.6	12.9
Tyler	33	240.6	5.6	-2	-35	2.3	3.5	459.9	8.8	-1	-30	1.9	2.7
Uniroyal	32	557.0	34.0	-5	-11	6.1	6.5	1,065.0	55.0	-3	-5	5.2	5.3
U.S. Steel	6	5,100.0	45.0	4	-6	0.9	1.0	9,600.0	32.0	-1	-59	0.3	0.8
Upjohn	13	543.3	52.2	8	8	9.6	9.5	1,019.6	107.2	1	-7	10.5	11.4
Vulcan Materials	30	264.6	25.6	2	0	9.7	9.9	468.1	30.6	1	-5	6.5	7.0

a From continuing operations excluding significant nonrecurring and extraordinary items. b Earnings as a percentage of sales. def = deficit.

The strength of the dollar was an oft-repeated theme throughout chemical company statements in the second quarter. About the least critical comment came from Ken W. Butterworth, president and chief executive officer of Loctite: "Our international business, which accounts for about 40% of our worldwide

sales, continued very strong in local currency. When translated into stronger dollars, these showed modest growth."

Hercules chairman and chief executive officer Alexander F. Giacco says, "Most of the 34 cents [per share] decline in operating earnings originated in Hercules Specialty

Chemicals Co. and equity in income of affiliated companies. This decline was largely due to the effects of the dollar's increased strength against foreign currencies."

Pricing also came in for its share of credit for the quarter's lackluster performance. National Distillers & Chemical chairman and chief exec-

utive officer Drummond C. Bell says that his company's disappointing results are attributable principally to depressed selling prices for both low- and high-density polyethylene and reduced sales for acetic acid and vinyl acetate. Earnings at National Distillers plummeted 70% in the quarter on a 6% decline in sales.

John M. Henske, chairman and chief executive officer of Olin, whose earnings dipped 54% on a 4% sales decline, says, "Imports, aided by the relative strength of the U.S. dollar, kept prices for many of our products at levels below last year."

One of the product areas strongly affected by price in the quarter was fertilizers, which have been a long-term drain on many companies' earnings. Williams Cos.' Agrico Chemical Co. registered a second-quarter operating profit of \$17.2 million, down from \$24.6 million in the same period of 1984. The company says that fertilizer sales volumes rose 13% over the second quarter of last year, but prices of most products were down from that period.

George J. Sella Jr., chairman of American Cyanamid, says, "As we anticipated, 1985 is turning out to be a very difficult year, primarily in the chemical and fertilizer industries." He attributes the company's 38% decline in earnings to the continuing effect of the strong U.S. dollar, the related increase in foreign price competition in chemicals, and overcapacity and lower selling prices for chemicals.

W. R. Grace's agricultural chemicals business recorded a loss of \$1.4 million after taxes, compared with \$14.0 million in income in the second quarter of 1984. Grace says that healthy second-quarter fertilizer sales volume was offset by the industry's weak price structure, the key factor in this group's steep earnings decline.

Whereas fertilizers were performing poorly in the quarter, the other agricultural sector of the chemical industry, pesticides, was showing mixed results, with a good quarter at Dow Chemical, moderate at FMC, and well down at other companies.

Dow notes that its agricultural group turned in a particularly strong

Petrochemicals took drubbing in second quarter

Earnings from chemical operations at oil companies in the second quarter repeated their poor performance of the first three months of 1985, and provided no help to the industry already suffering from poor results in its oil and gas operations.

After-tax earnings for the chemical operations of six oil companies that break out such data fell 37% in the second quarter to a combined total of \$203 million. For the first six months of the year, combined earnings also were down 37% to \$347 million.

Oil companies' chemical earnings are fairly indicative of the state of the petrochemical industry, since most of their chemical operations are in petrochemicals. To judge from these results, the petrochemical industry, although still making money, is far worse off than it was a year ago.

At Exxon, the third largest U.S. chemical producer, chemical profits fell 47% to \$72 million in the second quarter from the same period a year ago. Chairman Clifton C. Garvin Jr. says of the company's chemical unit, "Sales volumes of prime products were up 2% in the U.S. and 5% abroad,

with increases primarily in basic chemicals and plastics. Margins were depressed worldwide [because of] continued overcapacity and offset the effect of improved sales volumes."

Shell president John F. Bookout says that chemical sales volumes were about the same as last year, but that margins declined as lower selling prices more than offset the benefit of reduced feedstock costs. He adds that selling prices were lower in most business lines, particularly in commodity chemicals such as vinyl chloride and olefins.

Amoco says that sales volumes in all major chemical product lines remained strong, but results were adversely affected by lower margins. Capacity utilization for Amoco's chemical and polymer facilities increased to 88% from 79% in the second quarter a year ago.

Mobil, however, claims improved margins in the plastic packaging and consumer products parts of its chemical business. It says, though, that these only partly offset depressed petrochemical margins, caused by an oversupply situation.

EARNINGS ON CHEMICAL OPERATIONS

\$ Millions	Second quarter		% change	First half		% change
	1985	1984		1985	1984	
Amoco	\$50.0	\$ 57.0	-12%	\$ 99.0	\$116.0	-15%
Atlantic Richfield	18.0	30.0	-40	33.0	47.0	-30
Exxon	72.0	135.0	-47	152.0	256.0	-41
Mobil	18.0	29.0	-38	11.0	42.0	-74
Shell	35.0	58.0	-40	49.0	79.0	-38
Texaco	10.0	12.0	-17	3.0	9.0	-67

performance. At FMC, sales of agricultural chemicals increased in the second quarter as pyrethroid sales rose and furadan insecticide-nematicide production returned to normal. The company says that expenses associated with procuring methyl isocyanate for furadan production were reduced in the second quarter, but remained higher than 1984 levels. At Rohm & Haas, however, chairman Vincent L. Gregory Jr. says, "The seasonal decline in agricultural chemicals was larger than normal [because of] competitive pricing pressures on Stam herbicide in North America and Di-

thane fungicide in Europe, and price controls in Latin America."

Corporate executives are continuing to become more pessimistic as the year goes on. Rohm & Haas' Gregory says, "The second-quarter performance was in line with our expectations and confirms our previous comment that, in 1985, Rohm & Haas will not match its record earnings performance of 1984."

Olin's Henske says, "Barring an unexpected major improvement in overall economic performance, Olin's earnings for all of 1985 will be considerably below those of last year." □

Drab First Half for Canadian Chemicals

Canadian chemical executives are an optimistic lot. With very few notable exceptions, sales during the second quarter were down or unchanged from a year before; earnings tailed off even more. Both sales and earnings for the entire first half are nothing to write home about.

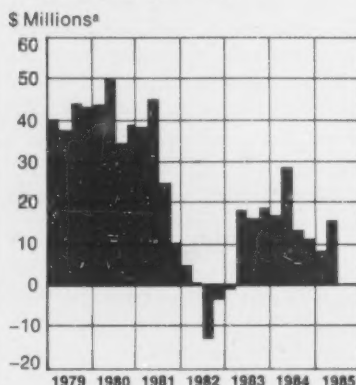
Yet, most of Canada's top chemical leaders see bluer skies ahead. With fingers crossed, they agree with those Canadian economists who say that lower interest rates will help keep the country's economy moving moderately upward. Real gross national product likely will rise 3 to 4% this year and by something slightly less than that in 1986.

For these and other reasons peculiar to their own companies, Canadian chemical executives aren't too distraught by a generally lackluster performance in the first half.

W. Norman Kissick, chairman of Union Carbide Canada, for instance, says that he expects improvement in that company's performance for the balance of the year. Improvement will be welcome because Carbide Canada lost \$2.6 million (\$1.00 = 1.36 Canadian dollars, June 30) on sales of \$223 million (down from \$262 million) in the first half.

Carbide, stung more than most by Canada's past energy policies, probably will benefit now that new policies will allow market pricing for energy and feedstock products. And the company no longer will be burdened by losses chalked up by

Combined earnings rose in second quarter



■ After-tax earnings of four largest publicly reporting Canadian chemical companies—C-I-L, Celanese Canada, Du Pont Canada, and Union Carbide Canada. Figures are converted from Canadian dollars using each year's average exchange rate.

50%-owned Pétromont in Montreal (the Quebec government is sustaining those operations) and by Petrosar in Sarnia (Carbide sold its stake to Polysar earlier this year).

Like Carbide, Du Pont Canada also sold its interest in Petrosar to Polysar. Unlike Carbide, however, Du Pont Canada shows a profit for the first half of the year.

Nevertheless, the company is struggling. Its \$447 million sales during the first six months is down 0.8% from last year. But more significant, earnings have plummeted a hefty 77%.

A big reason why second-quarter earnings dropped from last year's

\$11.5 million to only \$666,000 this year was a \$6.2 million after-tax charge covering a voluntary early retirement program. In addition, one-shot extraordinary losses involving the Petrosar sale and the closing of its lead alkyl unit in Maitland, Ont., totaled \$34.4 million. Net result for Du Pont Canada: a six-month loss of \$29.8 million. Despite these early-year setbacks, Du Pont Canada chairman J. Edward Newall expects that demand for the company's products will improve gradually over the remainder of the year.

Meanwhile, at Celanese Canada, executive vice president Robert J. St. Jacques thinks that the third quarter will be better for that company than last year's comparable period. He sees the trend that developed in the second quarter continuing for the rest of 1985. In the second quarter, both sales and earnings increased substantially over those in the first three months of the year. But for the entire first half, Celanese Canada's sales were down 8.9%, and earnings down a sizable 15%.

For Celanese, a big earnings improvement occurred in the chemicals division, where a combination of price increases, foreign exchange credits, and improved plant operating efficiencies yielded much better profit margins.

For C-I-L, however, profit margins for several chemical products, particularly fertilizer and polymers, are under heavy pressure. This, says chairman and chief executive officer C. H. (Chuck) Hantho, is because lower economic growth rates in North America and overcapacity are keeping a lid on price increases. Yet, perhaps because of its diverse product line, C-I-L fared better than most Canadian chemical companies in the first half. Sales increased 5.3% to \$486 million, and profits advanced a healthy 14% to \$18.6 million. And when the year is ended, Hantho expects C-I-L's bottom line to be better than it was last year.

Earl Anderson, New York

Sales slide in first half, and earnings slide even more

\$ Millions ^a	FIRST-HALF 1985					
	Net Sales	Change from 1984	Net Income ^b	Change from 1984	Profit margin ^c	1985 1984
C-I-L	\$ 485.9	5.3%	\$18.6	13.6%	3.8%	3.5%
Celanese Canada	133.9	-8.9	4.1	-15.4	3.0	3.3
Du Pont Canada	446.9	-0.8	4.7	-77.1	1.0	4.5
Union Carbide Canada	223.3	-14.6	-2.6	d	d	1.3
TOTAL	\$1290.0	-2.3%	\$24.8	-45.1%	1.9%	3.4%

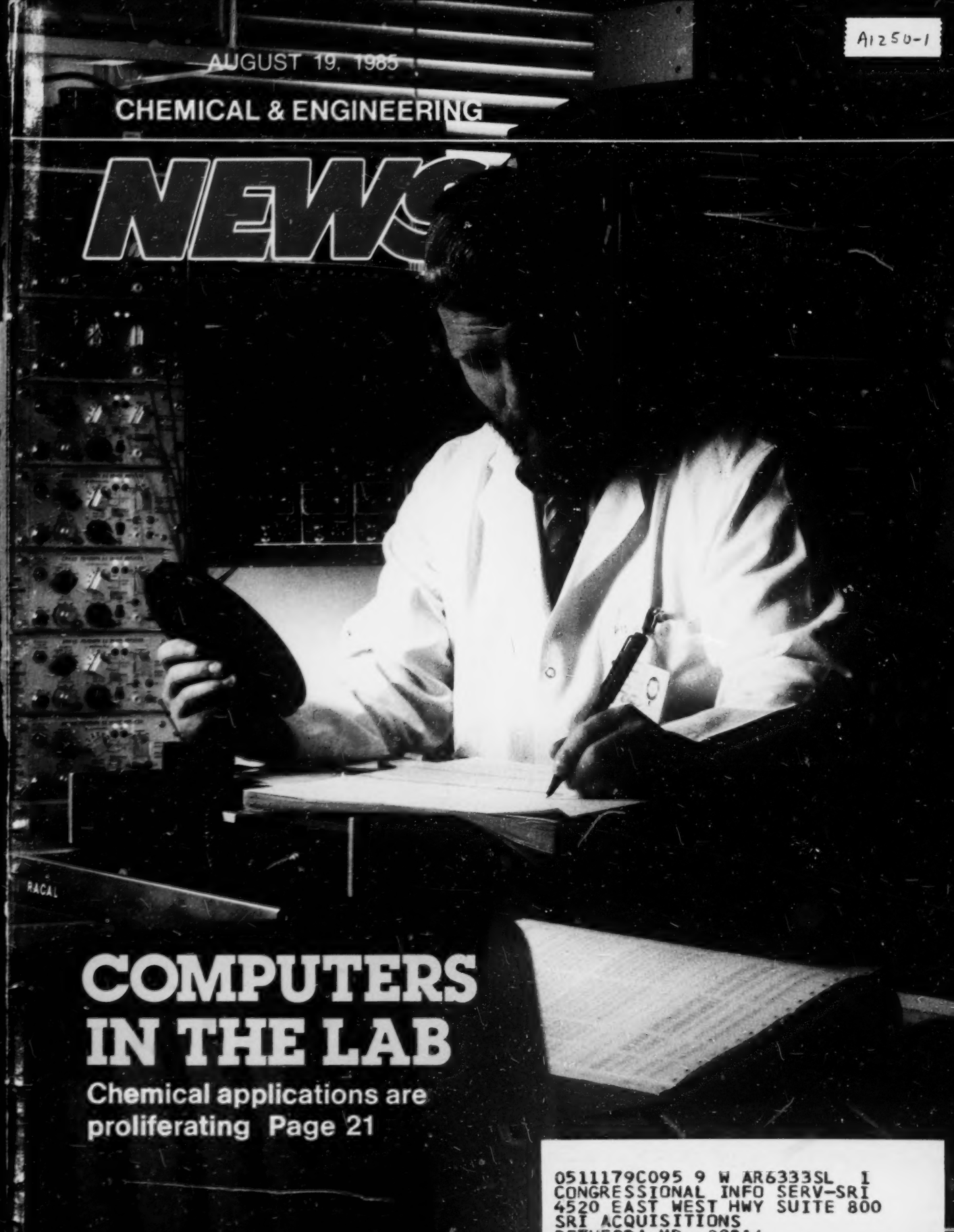
^a \$1.00 = 1.36 Canadian dollars, June 30. ^b Net income from continuous operations, excluding extraordinary gains or losses. ^c Net income as a percentage of sales. ^d Deficit in 1985.

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CHEMICAL & ENGINEERING

NEWS



COMPUTERS IN THE LAB

Chemical applications are
proliferating Page 21

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News of the Week

■ Accidents at Union Carbide's plants in West Virginia put company's safety practices back in the spotlight. **Page 4**

■ Hazardous materials figured in three incidents last week—a leaking tank truck, a ruptured tank pipe, and a train derailment. **Page 6**

■ EPA's refusal to regulate benzene air emissions from certain sources opens door to litigation by environmental group. **Page 6**

Cover: Computers aid Pfizer scientist's research on calcium-channel-blocking agents

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Business

Focus at DNA Plant Technology is on designing food products for processors, consumers, using cellular-level technology. **Page 9**

More and more car makers are accepting alcohol fuels, although some firms, such as Chrysler, aren't sold on methanol. **Page 11**

International Business

Japanese chemical industry's recent economic recovery is slowing down, especially for petrochemical, plastics output. **Page 12**

Government

Effect of EPA's proposed effluent guidelines on organic chemical, plastics, and synthetic fibers firms could be costly. **Page 14**

EPA should find a permanent solution to clean up Love Canal waste site, says Congressman displeased with agency's plan. **Page 15**

Education

Value of undergraduate research is getting more recognition, but finding adequate funding is still an uphill battle. **Page 17**

Books

"Radiant Science, Dark Politics," by Martin Kamen is the author's account of science in the age of discovery in nuclear physics and biochemistry as well as of the politics of science. **Page 49**



Special Report

Computers no longer are strangers to chemists; through lower-cost hardware and more easily available sophisticated software even the small research lab can support a microcomputer. **Page 21**

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LETTERS

Human failure

SIR: I detect a similarity between the Bhopal disaster and the hijackings that terrorize travelers. In both cases instrumentation safeguards have been provided, but disaster strikes because of human failure. In chemical plants, safety instrumentation, with backup devices, protect against mishaps. However, whenever this equipment is bypassed, intentionally or unintentionally, and insufficient or no routine followup is provided, disaster strikes, and in the case of Bhopal, it assumed enormous proportions.

When traveling by air, I often passed similar electronic equipment at the airport; in some cases, a bunch of keys, etc., caused the alarm to go off, but not in others. Some equipment was more sensitive, or properly adjusted, or possibly checked more frequently than that at other airports.

Thus, the dedication of the people that design, calibrate, operate, and performance-check the safety devices is as important as the devices themselves.

R. Pick
Hollywood, Fla.

Nuclear defense

SIR: I want to state my thanks for the clear illumination of the murky world of nuclear defense and nuclear deterrence in Michael Heylin's editorials of June 10 and 17.

Taken together, the editorials make two points on which I would like to expand. 1. Using our technological edge are we trying to construct a shield and a more effective spear at the same time? Past experience with using a technological approach has always ended with a much more dangerous position for both the superpowers and the rest of the world.

2. The arguments of the weapons labs should be viewed as possibly self-serving. On the one hand they argue that our weapons are less robust than the Soviets' because they rely heavily on high tech, and on the other hand they argue that the Soviets have developed extremely accurate first-strike weapons, which must be based on the cutting edge of technology. If the arguments are put together they are saying that the Soviets have both sophisticated and robust weapons. Assuming all their arguments are correct, our weapons labs have ill served the U.S. in comparison with their opposite number in the U.S.S.R.

While the workers in our weapons facilities are bright and decent individuals, they do have a vested interest in keeping the facilities viable and expanding.

Besides a comprehensive test ban, it would

be very useful to get an agreement to stop testing long-range rockets. Using dummy warheads these tests lead to increased target accuracy, a most dangerous component for hair-trigger response.

I believe it is of the utmost importance to seriously engage in mutual confidence building. While the ideals of our open society are in serious conflict with the Soviets' ideals based on a closed society, we should concentrate on the overwhelmingly important mutual bond between us, which President Eisenhower succinctly stated: "We will have either mutual survival or mutual suicide."

We could start with a crisis center, first suggested by the late Senator Jackson, peopled by various kinds of experts from both the North Atlantic Treaty Organization and Warsaw Pact countries. It could be sited in Geneva and have instant communication with all the political leaders to cool any crisis before it got out of hand.

Alvin S. Gordon
Encinitas, Calif.

Halogenated compounds

SIR: Through the years since its inception, the Environmental Protection Agency has been eliminating one halogenated compound after another when careful investigation has shown such a compound to be hazardous. Does it not seem reasonable now on the strength of this exhaustive research to generalize about the hazards of all halogenated organic compounds that may find their way into the body?

I don't think that dioxin (the 2,3,7,8-tetrachlorodibenzo-*p*-dioxin version) is an exception to the dehalogenation phenomenon. It is this particular dioxin's geometry (symmetry) that gives it extraordinary stability and enables the structure to survive except, unfortunately, in areas of high metabolic activity. In a certain sense, all the investigations of the relative toxicity of the halogenated compounds are actually studies of the rate at which dehalogenation occurs in aqueous environments.

Correction

• June 10, page 48: Employment for Celanese in 1984 was 21,500, not 36,000. As a result of this change, total employment in 1984 for the companies listed in the top table was 520,800, a change of -0.2% from the previous year; sales per employee in 1984 were \$125,800 in current dollars and \$43,600 in constant 1972 dollars.

Effluent Rules Could Have Harmful Effect on Chemical Industry

Most stringent proposals for water pollutants from organic chemical, plastics, synthetic fibers industry would be costly and cut about 10,000 jobs

An economic analysis of the effect of regulations being considered by the Environmental Protection Agency to control water pollutants from the organic chemical, plastics, and synthetic fibers industry says the rules could have pronounced impact on the industry. If the most stringent effluent control guidelines are adopted, the industry could spend more than \$1.4 billion in capital investments, and lay off nearly 10,000 workers. That extreme case is not likely to happen, but any of the proposed control levels would have an adverse impact on the industry.

First published in March 1983, the regulations are expected to be completed by spring 1986. They will put additional controls on companies at two levels. The first level is best practicable technology (BPT),

which is designed mostly to control so-called conventional pollutants, measured by biochemical oxygen demand and total suspended solids in the effluent. Chemical plants use this routinely to control pollutants. The second level is best available technology economically achievable (BAT) and is used to control particular chemical contaminants, especially those EPA calls priority pollutants.

In the Standard Industrial Classification system, the plants affected by the controls fall under five major headings. These are SIC 2821 (plastic materials and resins), SIC 2823 (cellulosic man-made fibers), SIC 2824 (organic fibers noncellulosic), SIC 2865 (cyclic crudes and intermediates), and SIC 2869 (industrial organic chemicals not elsewhere classified). Those headings are subsequently divided into 11 subgroups. Together, the plants in these categories make up probably the biggest grouping of chemical plants regulated by the agency.

EPA is considering different options for each of the BPT and BAT control categories, as well as regulations for effluent emissions into

municipal water treatment facilities. The most stringent options carry the largest price tags and could have the most impact. EPA's economic forecast concludes that the cost of control of conventional pollutants using BPT would be about the same regardless of the option, but great variations arise when considering the cost of the various BAT controls for priority pollutants.

For the most stringent option, BAT controls would be based on biological treatment, in-plant pollution controls, and postbiological treatment by activated carbon adsorption for any remaining toxic pollutants. It is this option that could lead to layoffs of up to 10,000 employees.

The economic projections were made for EPA by Meta Systems of Cambridge, Mass., and are based on about 4000 surveys mailed by EPA to chemical companies. From these it was determined that there are almost 1000 plants comprising the industries affected by the rule. EPA officials say about 200 of those plants are zero dischargers—that is, no pollutants are released from the plant site. The more than 700 remaining plants are expected to experience additional costs no matter what level of control is finally adopted.

According to the analysis, about half those plants, 304, would spend a total of \$290 million to control conventional pollutants under EPA's proposed regulations. Based on the survey information, at least four of those plants are in shaky enough financial condition that they might close rather than try to meet the stringent standards. The impacts of BPT controls vary by type of plant. The analysis claims that plants manufacturing organic chemicals, specialty organics, or thermosets would have to pay the greatest costs.

Analysis shows variety of harmful effects of water rules

	Best practicable technology	Best available technology	Pretreatment standards
Number of plants incurring costs	304	306	404
Cost of compliance (\$ millions)			
Capital investment	\$194.2	\$1437.1	\$303.8
Operation & maintenance	\$ 82.4	\$ 400.9	\$107.7
Total annual cost of compliance	\$136.9	\$ 676.8	\$166.1
Median profitability reduction	8.8%	33.9%	32.5%
Median production cost increase	0.6%	2.4%	2.5%
Median liquidity reduction	5.8%	26.6%	21.7%
Plant closures	4	20	19
Product line closures	6	19	37
Employment reduction	251	9606	1595

Note: Assumes most stringent options for all categories. BAT expenses include costs and impacts of stringent BPT controls. Source: EPA estimates

Much bigger expenses across the board would be incurred under the rules proposed for cleaning up the priority pollutant chemicals. BAT controls (coupled with the conventional controls) could have an initial price tag of \$1.4 billion in capital costs. Of the 11 subdivisions in this category, the hardest hit again would be plants making bulk organics, specialty organics, and thermoset plastics. Under the most stringent control option, the two organic chemical subgroups alone could lose up to 3604 jobs, with the closing of 12 plants out of 87 plants affected. In addition, a number of individual product lines in each of the categories would be eliminated.

A third major category of standards that would seriously affect this large group of industries is pretreatment standards for existing sources (PSES). The EPA analysis finds 404 plants that release toxic metals and organic pollutants into publicly owned treatment works. The subcategory hit hardest by EPA's pro-

posed pretreatment standards is specialty organics, where productivity could be cut 40% when these standards are combined with the other regulations the industry would have to comply with. Fourteen plants would have to shut down all or part of their operations, according to the analysis.

An area where the higher costs of making chemicals might be expected to have an impact is chemical foreign trade. However, the analysis claims that even the most stringent standards for BAT would have minimal effect on this important area.

EPA says it will accept comments on this study, as well as on the proposed regulations, until Oct. 15. To obtain a copy of the draft economic analysis of the effluent limitation standards for the organic chemicals, plastics, and synthetic fibers industry, write to EPA, Analysis & Evaluation Division (WH-586), 401 M St., S.W., Washington, D.C. 20460. □



LaFalce: EPA's option fatally flawed

In a letter to Thomas, LaFalce writes that thermal destruction of dioxin-contaminated wastes is a proven and cost-effective technology. This runs contrary to the advice EPA received from CH2M-Hill.

The OTA study, which LaFalce requested, says that a mobile pyrolytic destruction unit called the Huber Advanced Electric Reactor has proven itself at Times Beach, Mo. There, the unit destroyed dioxin in the tainted soils to levels below 1 ppb, the EPA standard, with virtually no release of toxic air pollutants.

The Huber unit is now available commercially. If used at Love Canal, cost of permanent cleanup would be about \$60 million, OTA estimates, far lower than CH2M-Hill's \$100 million estimate. CH2M-Hill figures the cost of interim storage at only \$10 million. But as OTA points out, this low figure does not include monitoring costs, nor does it include the eventual cost of permanent cleanup.

LaFalce urges Thomas to implement a permanent cleanup solution now. He writes Thomas: "To have the lowest cost for permanent technology is to purchase it today when companies are eager to prove their technologies effective and [when they] may be more willing to cut profit margins, or even [take] a 'loss-leader' approach."

Lois Ember, Washington

Permanent cleanup at Love Canal urged

Rep. John J. LaFalce (D-N.Y.), unhappy with the Environmental Protection Agency's cleanup decision at Love Canal, has asked EPA Administrator Lee M. Thomas to convene a working group to develop a permanent solution for cleaning up the dioxin-contaminated wastes at this infamous hazardous waste site in Niagara Falls, N.Y.

In its May 6 "record of decision," which relies on a contractor's study, EPA calls for interim storage of the wastes either in a concrete vault or in a berm facility, which is a type of landfill. There is no mention of just how interim the storage would be, although an Office of Technology Assessment study of the record of decision and other documents states "there are hints that interim storage might be in effect for as long as 20 years."

According to OTA, EPA's cleanup option is flawed on several counts. The use of a concrete vault for the storage of hazardous waste is untested. A berm facility is plagued by the deficiencies of other forms of landfill: deterioration

and failure over time. The costs associated with interim storage are probably underestimated by EPA and its contractor CH2M-Hill. OTA says EPA and CH2M-Hill have neglected to factor in the costs of continuous environmental monitoring and the costs of corrective actions should the storage facility fail.

LaFalce thinks EPA's option is fatally flawed because it fails to consider "long-term permanent solutions for the cleanup of Love Canal." According to an aide, LaFalce "will accept nothing less than a permanent cleanup. A top priority has to be habitability of the viable community of Niagara Falls."

In July, LaFalce got EPA Administrator Thomas' commitment to a permanent cleanup solution, LaFalce's aide says. Staff members from LaFalce's office and EPA are working on legislative language that will spell out this commitment, and such legislation is likely to be introduced this session. Thomas has yet to respond to the Congressman on the formation of a working group to develop a permanent cleanup solution.

AUGUST 26, 1985

NEWS

Affinity Chromatography

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News of the Week

■ U.S. shipments of plastics were higher in first-half 1985 than in first-half 1984, but rate of growth declined. **Page 4**

■ EPA may lower or eliminate liability requirements for hazardous waste sites. **Page 4**

■ Suit filed against Union Carbide on behalf of victims of Institute, W.Va., gas leak. **Page 5**

■ First industrial unit in space will be launched by NASA for Space Industries Inc. **Page 5**

■ State Department accuses Soviets of using mutagenic tracer chemical on U.S. embassy personnel. **Page 6**

Cover: Light microscope view of human red blood cells bound to wheat germ agglutinin that is immobilized on agarose beads. Affinity chromatography using this or other immobilized plant lectins can isolate intact cells or broken cell membranes

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Business

Second-quarter profit margins for most U.S. pharmaceutical firms were higher than those of second-quarter 1984. **Page 8**

Government

Initial publication of Administration's regulatory policies, goals, and priorities provides for Presidential oversight of regulatory process, enhances understanding of its objectives. **Page 10**

Dioxins found in soil samples near the Niagara River during survey of dumpsite under EPA's National Dioxin Strategy. **Page 11**

Science

Two new computer systems designed for organic chemists are less complicated, can be used with personal computers. **Page 13**

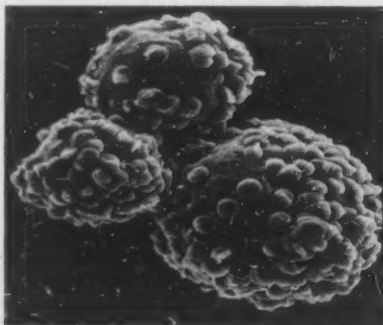
Biotechnology is received favorably by leaders in science policy, environmental issues, and religion, survey shows. **Page 16**

Books

"Orphan Drugs: Medical vs. Market Value" points up dilemma of pharmaceutical firms whose R&D expenses for compounds to treat rare disease far outweigh profits derived from them. **Page 33**

ACS News

ACS Board of Directors approves Petroleum Research Fund grants of \$4,048,582, bringing 1985 total to record amount. **Page 35**



Special Report

Affinity chromatography has been used to study cell interactions and mechanisms of enzyme actions, as well as to solve problems in treatment of disease. **Page 17**

PLASTICS:

Growth is continuing, but slower

Shipments of thermoset and major thermoplastics in the U.S. were up in the first half of 1985 over the comparable period a year ago, but growth is slowing.

According to the latest figures from the Society of the Plastics Industry's Committee on Resin Statistics, and compiled by accountant firm Ernst & Whinney, plastics shipments in the first half totaled 20.6 billion lb, 4% more than in first-half 1984. That rate is slower than the 6% growth in 1984, when shipments totaled 39.7 billion lb.

The SPI figures show shipments of thermosetting resins in the first half were down less than 1% to 2.83 billion lb. In 1984, thermoset demand grew 4%. And thermoplastic shipments in the first half totaled 17.8 billion lb, up 5% from a year earlier, but that's less than the 7% rate for full-year 1984.

Within the thermoplastic category, the five largest—low-density polyethylene, high-density polyethyl-

ene, polypropylene, polystyrene, and polyvinyl chloride—which together account for more than 90% of total thermoplastic shipments and almost 80% of all plastic shipments, grew at a 6% rate in the first half, the same rate as in 1984.

The largest growth among these five was for low-density polyethylene, whose shipments increased 10% in the first six months to 4.46 billion lb. That was followed by high-density polyethylene's 9% growth to 3.13 billion lb, polypropylene's 8% increase to 2.59 billion lb, and polystyrene's 5% rise to 2.02 billion lb. Only PVC lost ground, dropping 4% to 3.32 billion lb.

Within the thermosets, only urea resins showed any growth in the first half, with shipments rising 2% over first-half 1984 levels to 622 million lb. Shipments of phenolics showed essentially no change at 1.29 billion lb, polyester's dropped 1% to 634 million lb, melamine's fell 4% to about 97 million lb, and epoxies' dropped 6% to 189 million lb.

Despite the constant complaining by chemical company executives of the strong dollar and its effect on international competition, exports of thermoplastics during the first half of 1985 performed well. According to the SPI figures, exports of the five major thermoplastics increased more than 13% in the half to almost 15 billion lb. This growth was led by LDPE, exports of which grew almost 39% to 552 million lb. Exports of both HDPE and polypropylene grew 11%—to 367 million lb and 395 million lb, respectively. However, polystyrene's small-volume exports shrank almost 9% to 44 million lb, and PVC's dropped more than 25% to 140 million lb.

Based on the first-half rates, if the economy continues at its present pace, there is little reason to

expect anything other than moderate growth for plastics during 1985, leaving plastics producers with a relatively good year in demand. But with price pressure resulting from anticipation of declining oil prices, profitability probably will remain a problem. □

Options eyed for waste site liability insurance

When the Environmental Protection Agency proposed that the liability insurance requirement for owners and operators of hazardous waste sites be eliminated, there was such an outcry that the agency made a quick turnaround and promulgated liability regulations that became effective in 1982. But the situation has changed again, and EPA is considering new options on such coverage, including easing or dropping the requirement.

Third-party liability insurance in the regulation covers bodily injury and property damage resulting from both accidental sudden releases and nonsudden releases of toxic compounds during the operating life of a facility. However, recent losses by the insurance industry, both from high claims payments and falling interest rates, have resulted in a serious decline in the number of companies that offer such insurance and a large increase in premium payments. This situation is the reason for EPA's proposed changes.

Five alternatives are being considered. The first is to maintain the present system, which specifies a minimum coverage of \$3 million per occurrence and \$6 million total annually. One company reported to EPA that such coverage cost it \$99,000 recently. Because of the

Thermoplastic shipments increase in first half

Billions of lb	First half	Change from 1984
Total thermosets	2,834.5	-1%
Epoxy resins	189.1	-8
Polyester	633.9	-1
Urea	622.3	2
Melamine	96.5	-4
Phenolic	1,292.7	0
Total thermoplastics	17,806.1	5
Low-density polyethylene	4,460.1	10
High-density polyethylene	3,127.9	9
Polypropylene	2,593.9	8
Polystyrene	2,024.4	5
Polyvinyl chloride	3,323.0	-4
Other	2,271.0	0
GRAND TOTAL	20,634.5	4

Source: SPI Committee on Resin Statistics

expense and problems of availability, that option surely would cause some facilities to close. Other alternatives are to lower the scope of coverage, authorize different financial responsibility mechanisms such as corporate guarantees, issue case-by-case waivers of the current requirements, and suspend or withdraw the insurance requirements altogether.

EPA says that only 10 states still have to follow EPA rules on insurance requirements. Other states have their own financial regulations. If the requirements are changed, however, states may adopt similar alternatives subject to EPA approval. Whatever happens, waste facility operators must follow the requirements approved in their state. □

Carbide sued over Institute chemical leak

A group of attorneys last week filed lawsuits against Union Carbide on behalf of victims of the Aug. 11 toxic gas leak at the company's Institute, W.Va., chemical facility. The lawyers, all of whom are also involved in the multibillion-dollar, Bhopal-related litigation consolidated in Federal District Court in Manhattan, filed the suits in the Manhattan court and in the Kanawha County Circuit Court in Charleston, W.Va.

In total, the suits seek about \$88 million in compensatory and punitive damages on charges that Carbide failed to warn the public adequately of the danger of leaks and failed to maintain an effective warning system.

Although the chemicals involved in the Institute leak were completely different from those in the December 1984 Bhopal disaster, it is thought that lawyers may be able to obtain information in pretrial examination of company witnesses in the Institute case that could be useful to them in the Bhopal case. Pretrial questioning in the Bhopal suits has been limited by the federal court (C&EN, Aug. 19, page 4).

In a press briefing, Carbide chairman Warren M. Anderson said the company is changing its emergency response procedures to remove

from plant managers the responsibility of deciding when a leak is serious enough to warrant a community alert. The company also appointed William D. Ruckelshaus, former administrator of EPA, to be special counsel to head a board-of-directors-level committee that will conduct an independent investigation of the Institute release. That study will be separate from the company's internal investigation, results of which were scheduled to be disclosed last Friday.

Meanwhile, information on the possible toxicity of the released chemicals—methylene chloride and aldicarb oxime—continued to surface. Carbide questioned preliminary findings of a University of Wisconsin study showing that low-level aldicarb oxime residues may affect the immune systems of mice. "[The study] will doubtless be debated both as to its methodology and its conclusions," said Eugene J. Boros, vice president of R&D of Carbide's agricultural products operation.

Various initiatives on methylene

chloride are under way by government agencies, following the results of a study by the National Toxicology Program reported in March. A bioassay of methylene chloride administered to rats and mice by inhalation led to a finding that there is enough evidence to conclude that the substance is carcinogenic in animals and that for practical purposes it could be regarded as presenting a carcinogenic risk to humans.

Among government agencies considering action is the Consumer Product Safety Commission. A briefing paper by the CPSC staff notes that preliminary exposure information indicates that the carcinogenic risks for consumer uses of paint strippers containing methylene chloride may be as high as three in 1000. Also, for aerosol spray painting operations using products containing methylene chloride, individual lifetime risks as high as 170 in a million were calculated. These risks, the CPSC staff says, are among the highest ever calculated for chemicals from consumer products. □

Pact signed for first industrial space unit

A small Houston-based firm will construct and operate the first privately owned industrial facility in space. Under an agreement signed last week between the National Aeronautics & Space Administration and Space Industries Inc., NASA will launch two modular units to be built by SII—which will make space in

them available to manufacturers—on space-shuttle missions in 1989 and 1990.

The facility, orbiting at an altitude of 265 miles, will be based initially on use of one modular unit and then on two linked units. The cylindrical units each measure 35 × 14.5 feet, have a volume of 2500 cu



Space Industries' president Faget holds model of industrial space facility

Drug Firm Profitability Continues To Rise

Thanks to production efficiencies and aggressive pricing, most pharmaceutical companies recorded higher profit margins in the second quarter of 1985 compared to the year-earlier period. For a group of 15 large drug and medical supply houses, the composite profit margin (after-tax earnings as a percentage of sales) rose to 12% from 11.5% in second-quarter 1984. The level marked the fourth consecutive quarterly increase in profitability.

On the other hand, composite sales for the group increased just 3% on an annual basis, and composite net income climbed 8%. Sales continued to be suppressed by the strength of the U.S. dollar against other currencies.

The largest gains in net income were registered by A. H. Robins, with a 29% increase, Pfizer 16%, Abbott Laboratories 15%, Bristol-Myers 13%, and Revlon 12%. The worst earnings performers in the group were Baxter-Travenol, down 8%; Eli Lilly, down 3%; and SmithKline Beckman, which managed just a 1% increase.

Abbott Labs, which continued its

strong performance with record sales and earnings for both the second quarter and the first half of 1985, attributed its improvement to continued productivity gains, an improved product mix, and a lower estimated effective tax rate. Company chief executive officer Robert A. Schoellhorn says he expects the company to achieve record sales and earnings for the 14th consecutive year in 1985.

Sterling Drug's 3% increase in net income on a 1% sales gain was achieved through a more favorable product mix, continued cost controls, and a decline in the effective tax rate, says John M. Pietruski, chief executive officer. The company recorded flat sales for pharmaceutical specialties, a modest gain for proprietary products, and a 14% rise in household and personal product sales. Chemical sales declined 5% for the quarter, however, and 6% for the six-month period. Sluggish demand and price competition are blamed for the fall.

Squibb reported an 11% increase in net income on an 8% sales rise. Richard M. Furlaud, chief executive

officer, points out that sales would have increased 16% if not for foreign exchange rate fluctuations.

At SmithKline Beckman, earnings were held to a 1% gain by a higher tax rate. Sales, which climbed 8%, were checked by large inventories of Tagamet, the ulcer medication that is the company's star product, accumulated during the first quarter. Over the six-month period, however, notes chief executive officer Henry Wendt, Tagamet sales grew both in the U.S. and in local foreign currencies.

Pfizer's 16% gain in net income compared to second-quarter 1984 came on a mere 1% rise in sales. If not for the strength of the dollar, the company says, sales would have grown 7% in the quarter.

At Merck, cost controls, productivity measures, and a changed product mix helped offset partly the impact of exchange rates, says P. Roy Vagelos, president and chief executive officer. Still, sales fell 2% for the quarter, the result of both the dollar's strength and two major divestments.

David Webber, New York

Earnings rose in the second quarter for most pharmaceutical firms

	SECOND-QUARTER 1985						FIRST-HALF 1985					
	Sales	Earnings ^a	Change from 1984		Profit margin ^b		Sales	Earnings ^a	Change from 1984		Profit margin ^b	
	(\$ millions)		Sales	Earnings	1985	1984	(\$ millions)		Sales	Earnings	1985	1984
Abbott Laboratories	\$ 827.0	\$115.0	3%	15%	13.9%	12.5%	\$1583.2	\$217.2	4%	15%	13.7%	12.4%
American Home Products	1113.0	167.1	4	10	15.0	14.1	2320.5	348.0	5	10	15.0	14.3
Baxter Travenol	499.8	43.6	6	-8	8.7	10.0	997.1	82.4	14	-1	8.3	9.5
Bristol-Myers	1079.8	125.9	2	13	11.7	10.5	2162.3	250.5	2	13	11.6	10.4
Lilly	756.8	110.1	5	-3	14.5	16.7	1665.7	271.0	3	4	16.3	16.1
Merck	877.4	137.9	-2	5	15.5	14.7	1733.7	269.5	0	5	15.5	14.7
Pfizer	1001.9	137.5	1	16	13.7	12.0	1953.8	284.9	2	15	14.6	12.9
Revlon	582.4	34.6	1	12	5.9	5.3	1133.6	62.7	-1	13	5.5	4.8
A. H. Robins	164.7	5.3	8	29	3.2	2.7	331.1	26.8	7	34	8.1	6.5
Schering-Plough	479.6	51.8	1	8	10.8	10.1	966.6	105.9	0	5	11.0	10.5
SmithKline Beckman	770.7	121.4	8	1	15.8	16.8	1540.7	253.2	8	1	16.4	17.5
Squibb	474.6	52.3	8	11	11.0	10.7	927.7	94.6	7	13	10.2	9.7
Sterling Drug	453.6	33.1	1	3	7.3	7.2	889.4	65.0	-2	3	7.5	7.1
Upjohn	543.3	52.2	8	8	9.6	9.5	1019.6	107.2	1	-7	10.5	11.4
Warner-Lambert	810.9	66.9	2	8	8.2	7.8	1605.5	126.7	2	9	7.9	7.4

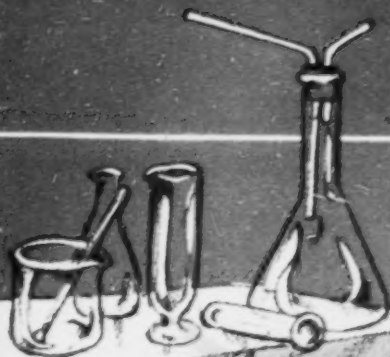
a Excludes significant extraordinary and nonrecurring items. b After-tax earnings as a percentage of sales.

SEPTEMBER 2, 1985

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CHEMICAL & ENGINEERING

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Early Retirement

Incentives again popular
in chemical firms

Page 9

News of the Week

■ Union Carbide plans drastic restructuring to rectify some of its problems, gives lengthy explanation of recent Institute leak. Page 6

■ Richard Heckert takes new post at Du Pont, is slated to fill Edward Jefferson's position as chairman of the board. Page 7

■ Proposed duties on some imports would save chemical jobs, but do more harm than good to overall U.S. economy. Page 8

■ Herbicide-resistant corn varieties are close to marketing stage. Page 8

Business

EPA expected to modify Du Pont waiver for methanol fuel blends, easing up on highly restrictive volatility requirements. Page 14

Government

Congressional report on drug diversion schemes reveals growing threat to safe drug supply. Page 17

Environmental group links rain sulfates in West to sulfur dioxide emissions from copper smelters. Page 18

Technology

First experiment in space attempting to grow organic crystals by vapor transport placed aboard *Discovery* by 3M Co. Page 22

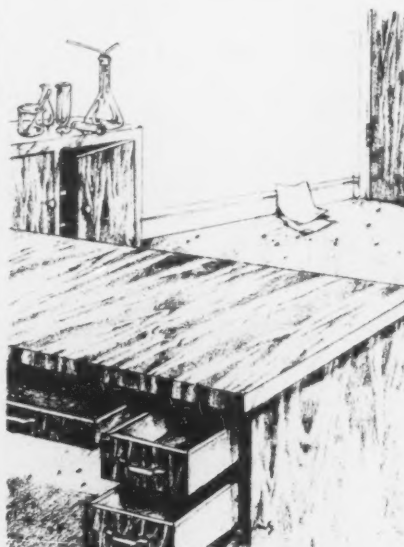
Education

Academic labs' problems of obsolete equipment may find relief from a number of actions recommended by study. Page 23

ACS News

Role of dues in ACS finances explained by the Society Committee on Budget & Finance. Page 26

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News Focus

Incentives for early retirement have been accepted by employees in the chemical industry with growing success, though other businesses find trend toward such incentives to be slowing. Page 9

CARBIDE RESTRUCTURES: Problems prompt massive cutback

In a dramatic attempt to rectify some of its problems, Union Carbide has announced it will shut down some of its chemical plants, sell others, and cut its salaried workforce by 4000. The consolidation, which will result in a pretax charge of about \$990 million, will subtract about \$8.00 per share from this year's earnings. Analysts generally praised the plan, calling it overdue but likely to aid the company's financial performance in the future.

The move comes on the heels of the firm's expiation of—and acceptance of responsibility for—the chemical leak last month at its Institute, W.Va., facility.

Focusing on its most troubled business segments, Carbide will write off \$325 million worth of petrochemical assets, \$370 million of metals and carbon products assets, and \$170 million worth of other assets. The company, which already has sold several units this year, will divest another \$500 million worth of business deemed nonstrategic. The identities of the units to be closed or sold have not been disclosed.

To reduce payroll, Carbide will offer early retirement incentives aimed at decreasing its salaried staff by 4000, or 15%, by early next year. The reduction, much of which probably will take place in Carbide's Danbury, Conn., headquarters, will result in a \$70 million pretax charge to 1985 earnings. After the reduction in force is completed, however, annual pretax savings will amount to about \$250 million, the company says.

Carbide also is taking steps to increase shareholder value. It will begin buying back up to 10 million shares of common stock (which closed last Wednesday at \$55³/₈) and will launch a debt reduction program. In addition, the company will alter its domestic pension plan to allow it to appropriate \$500 million in surplus funds, money that probably will be used to finance the stock repurchase program.

Carbide is committing \$220 million in total to a program to improve environmental protection and safety in the company. The remaining element in the decisions an-



Anderson: committed to safety

nounced last week involves changes in depreciation policies.

Announcement of the massive restructuring comes a month after a major reorganization that consolidated Carbide's five business groups into two (C&EN, Aug. 5, page 6). Both the management consolidation and the restructuring begun last week emphasize Carbide's interests in its industrial gases, consumer, and technology licensing businesses.

"The program being announced, together with the recent reorganization and the upgrading of our business portfolio, is evidence of our continuing commitment to achieving competitive leadership and to increasing shareholder return while committing to a goal of environmental protection and safety in all our operations," says Warren M. Anderson, Carbide's chief executive officer.

The announcement comes in the midst of takeover rumors, the continuing controversy over the gas leak disaster at a company subsid-

Decomposition products and solvent expelled from vessel

Compound	Amount released, lb	Compound	Amount released, lb
Methylene chloride	850	1,3,5-Trimethylbluret	75
Methyl isopropyl sulfide	550	1,3-Dimethylurea	75
Isobutyronitrile	500	Dimethyl sulfide	70
Aldicarb nitrile ^a	400	2,4-Dithiapentane	65
Dimethyl disulfide	300	2-Methylthiopropene	40
Methyl mercaptan	275	Isobutylene	9
Aldicarb amide ^b	250	Aldicarb aldehyde ^c	9
Trimethyl isocyanurate	150	Isopropyl chloride	9
Isobutyramide	125	Aldicarb oxime ^d	8
Acetone	95	Hydrogen sulfide	8
Volatile polymers	90	Propylene	7
Acetoxime	90		

^a α -Methylthioisobutyronitrile. ^b α -Methylthioisobutyramide. ^c α -Methylthioisobutyraldehyde. ^d α -Methylthioisobutyraoxime. Source: Union Carbide

iary in Bhopal, India, and recent chemical leaks at Carbide's Institute plant. At a press conference, the firm revealed the results of the investigation of the eruption on Aug. 11 of a reactor being used as a storage vessel at the Institute plant. Carbide chemists and engineers have concluded that an exothermic decomposition of aldicarb oxime was the most likely cause of the eruption. Of the 3800 lb of material expelled, 650 lb was methylene chloride solvent, 300 lb was solid residue in pipes from previous use of the reactor, and only 8 lb was aldicarb oxime itself.

Some of the compounds released were foul smelling as well as toxic. Jackson B. Browning, vice president of health, safety, and environmental affairs, says that such compounds as methyl mercaptan and dimethyl sulfide and disulfide persisted in the community at concentrations from 3 to 18 ppm for a half hour. Compounds related to aldicarb oxime reached concentrations of 10 ppm. Methylene chloride vapor extended beyond the fence limit at 22 ppm for a few minutes, Browning says.

As Carbide investigators reconstruct the incident, methylene chloride was piped into the aldicarb reactor on Aug. 1. Aldicarb oxime (α -thiomethylisobutyraldoxime) was introduced next. A malfunction in a flow meter caused too much oxime to be let in. Engineers installed a temporary pipeline to pump the solution into another 5000-gal, glass-lined reactor that had not been used since November 1984.

Unknown to Carbide operators, steam flowed through leaky valves into the jacket of this reactor from Aug. 1 to 7. The heat caused methylene chloride (boiling point 104 °F) to boil off from the oxime (boiling point 410 °F), raising the concentration of oxime from 38% to 81%. Methylene chloride was later found to have condensed in two connected vessels called the knockout pot and the crystallizer.

Not realizing that this change had occurred, Carbide operators tried to pump the reactor contents back into the aldicarb reactor on Aug. 7. After two and a half hours, the pump appeared not to be moving any more material, and it was shut off. Oper-

ators could not use level indicators to determine that the pumping was incomplete because the remaining 500 gal formed what is called a heel in the convex bottom of the vessel.

Steam continued to flow into the reactor jacket, and the temperature rose. To know that this was happening, operators would have had to cail up the display of the reactor's condition on the control-room computer. Thinking the reactor empty, they did not do this.

From laboratory experiments and computer simulations, Carbide investigators conclude that on the morning of Aug. 11, the reactor temperature reached 300 °F. This temperature initiated exothermic decomposition of the oxime. At 9:25 AM, a differential pressure alarm went off, indicating that a safety valve had burst and that a high flow of gas was flowing through the knockout pot and scrubber to the flare tower. An operator entering the control room heard a rumbling sound from the reactor. He looked toward

the flare tower and saw a lot of smoke. After four seconds, the differential pressure indicator dropped precipitously, indicating that other release valves had opened. The plant alarm was sounded at 9:26.

An opaque, white fume engulfed the yard and the control room, trapping five operators and their foreman. The men could not see the panels in front of them. At 9:32, the eruption ended. A minute later, the workers were led to safety. At 9:36 county officials were notified.

The reactor that erupted had last been used in November 1984 to react 2,4,6-trimethylphenol with methyl isocyanate. Methyl isocyanate was not involved in the incident of Aug. 11. There remained in the piping associated with the reactor a residue of such methyl isocyanate derivatives as 1,3-dimethylurea, 1,3,5-trimethylbiuret, and trimethyl isocyanurate. These solids (300 lb) were blown out along with aldicarb oxime decomposition products and methylene chloride. □

Heckert chosen to be next Du Pont chief

Du Pont has appointed current vice chairman Richard E. Heckert to a new post of deputy chairman of the board. The move positions Heckert to succeed chairman and chief executive officer Edward G. Jefferson when Jefferson retires next May 5. As deputy chairman, Heckert, 61, has operating responsibility for all Du Pont units and consolidated subsidiaries.

Succeeding Heckert as vice chairman is Edgar S. Woolard Jr., 51, who becomes responsible for Du Pont operations excluding Conoco.

Jefferson, who has been chairman and chief executive officer since 1981, says that "by announcing the appointments at this time, we pave the way for an orderly management transition at a time of important changes to improve the competitive position of our businesses." Besides the acquisition of Conoco, Du Pont in the past several years has been diversifying itself away from traditional chemicals and becoming more heavily involved in specialty chemical, biomedical, and electronics businesses.

Heckert, who joined Du Pont as a research chemist in 1949, has been a director and member of the executive committee since 1973. In 1981, when Jefferson became chairman of Du Pont, Heckert was made president and chief operating officer of



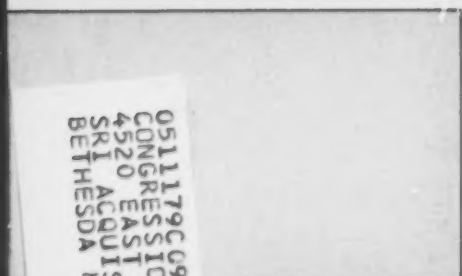
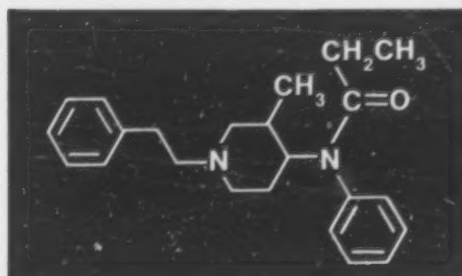
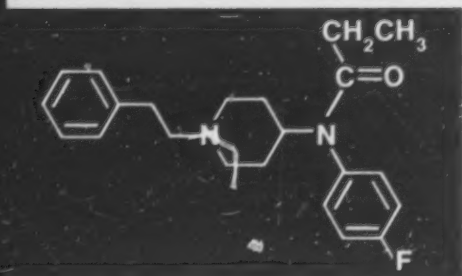
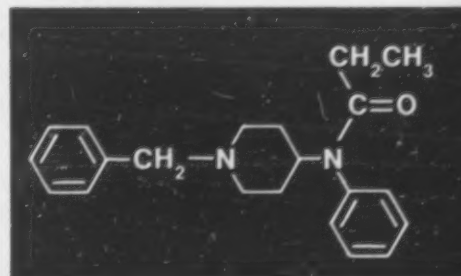
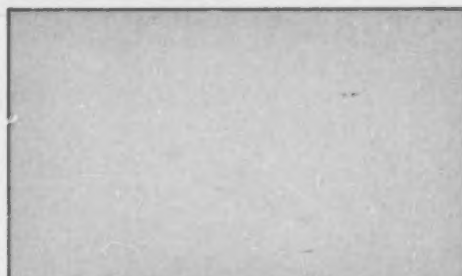
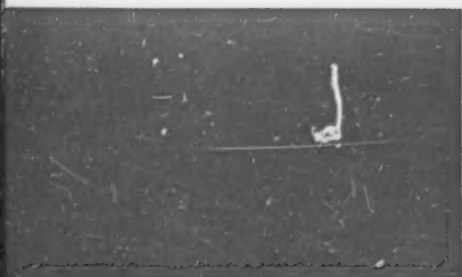
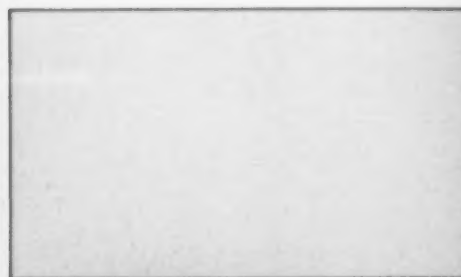
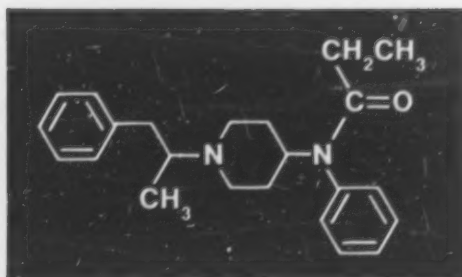
Heckert: appointed to new post

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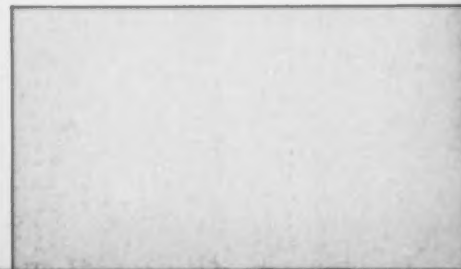
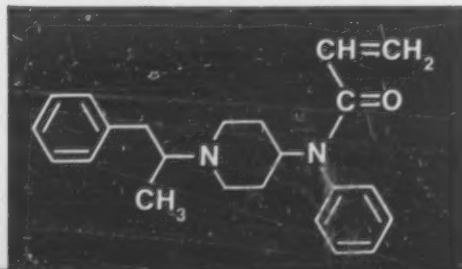
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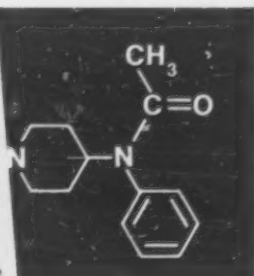


Designer Drugs

Underground Chemists Ply A
Deadly Trade Page 7



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News of the Week

■ Genencor scientists make rennin in filamentous fungi using recombinant DNA technique. **Page 4**

■ U.K.'s Hanson Trust ups ante on SCM takeover bid. **Page 4**

■ FDA approves marketing of the generic form of Valtrex. **Page 5**

■ EPA proposes 38 new hazardous waste sites for cleanup under the Superfund law. **Page 5**

■ New lab at Los Alamos will use ion beams to conduct research on materials. **Page 6**

■ MIT will set up center for research on bioprocess separations. **Page 6**

■ Court rules Hybritech biotech patent is invalid. **Page 6**

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Business

U.S. chemical companies increased cash, marketable securities an average of 22% in second quarter over first quarter. **Page 19**

Carbide restructuring is mix of long-considered streamlining plans and reaction to takeover threats, analysts say. **Page 20**

Government

Science and technology policies in the industrialized countries lack overall goals, vision of the future, says OECD report. **Page 22**

Technology

Nalco Chemical holds open house at Chicago site; neighbors tour plant areas, see warning systems, emergency equipment. **Page 24**

Film produced by fire fighters' union showing horrors of toxic gases from burning buildings fires the plastics industry. **Page 25**

Science

GE physicist uses nuclear magnetic resonance to analyze intact human heart for high-energy phosphate metabolites. **Page 25**

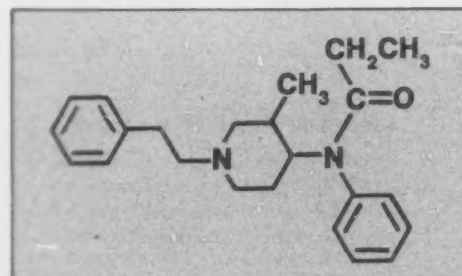
Synthetic metal becomes superconductive at 5 K, setting a record for superconductivity in an organic compound. **Page 26**

Books

"The Dose Makes the Poison" by M. Alice Ottoboni covers basics of toxicology and corrects some misconceptions. **Page 27**

ACS News

ACS announces 1986 award winners for achievement in chemistry, 1985 regional high school chemistry teaching honorees. **Page 30**



News Focus

Designer drugs—analogs of compounds with proven pharmacological activity—have hit the street, causing more headaches for law enforcers. **Page 7**

Chemical Companies Increase Cash Assets

Chemical companies seemed to take a more fiscally conservative approach to conducting business in this year's second quarter than in the first as the U.S. chemical economy continued in the doldrums. A C&EN survey of 13 large chemical companies indicates that, although earnings dropped, these firms apparently took a prerecessionary step toward cash management, reining in inventories, receivables, accounts payable, and short-term debt, and thus cutting day-to-day financing needs and increasing cash hoards. Although inventories and receivables are listed as current assets on corporate balance sheets, they require financing, thereby draining away cash and sometimes increasing short-term debt.

During the second quarter, according to the survey, the 13 companies increased their cash and marketable securities an average of 22% to a combined total of \$7.28 billion. During that period, they managed to keep current liabilities at the same levels as in the first quarter.

Thus the firms' "liquidity"—cash and cash coverage of liabilities—

increased. According to the survey, the average current ratio (total current assets divided by total current liabilities) increased slightly to 1.8 from 1.7 in the first quarter. Cash ratio (cash and marketable securities divided by total current liabilities) increased to 0.18 from 0.14 in the first quarter.

The comparisons for the second quarter with the same period a year before, however, are not so good. Although cash and marketable securities for the 13 firms dropped almost 6% year-to-year, the chemical firms raised their average current ratio to 1.8 from 1.7. But the cash ratio fell to 0.18 from 0.19, indicating that while cash was falling during the year, companies increased total current assets. Current liabilities for the two periods were about the same.

Almost all of the companies surveyed showed increases in cash in this year's second quarter, compared with the first quarter. Chemed gained the most in that respect, with cash and marketables increasing to \$11.2 million, 37 times what they had been in the first quarter. Free-

port-McMoRan's cash and marketables increased 600% to \$81.4 million, and those for First Mississippi rose 158% to \$13.4 million. Other big gains included a 78% increase for W. R. Grace, 37% for Air Products, 36% for American Cyanamid, 30% for Pennwalt, and 24% for Celanese. More-modest gains included 6% for Monsanto and 5% for Ethyl Corp.

Only three companies showed declines in cash and marketables. Carbide's dropped 3%, National Distillers' 9%, and Dow's a precipitous 68%.

The companies with only modest cash increases tended to have the best ratios in the second quarter, however. Monsanto, Ethyl, and National Distillers each posted a current ratio of 2.3. Monsanto's cash ratio of 0.35 was third behind American Cyanamid with a very good 0.64 and Freeport-McMoRan with 0.43. Other above-average cash ratios include 0.31 for Pennwalt, 0.23 for First Mississippi, 0.22 for Grace, and 0.21 for Chemed. Carbide and Dow figures were a dismal 0.05 and 0.02, respectively.

William Storck, New York

Cash assets for 13 chemical firms up 22% in second quarter

	SECOND-QUARTER 1985			FIRST-QUARTER 1985			SECOND-QUARTER 1984		
	Cash and marketables (\$ millions)	Current ratio	Cash ratio	Cash and marketables (\$ millions)	Current ratio	Cash ratio	Cash and marketables (\$ millions)	Current ratio	Cash ratio
Air Products	\$ 74.0	1.5	0.17	\$ 53.9	1.5	0.14	\$ 62.4	1.2	0.14
American Cyanamid	551.6	2.1	0.64	406.8	1.9	0.44	397.5	2.0	0.47
Celanese	167.0	1.5	0.17	135.0	1.7	0.16	173.0	1.7	0.27
Chemed	11.2	2.0	0.21	0.3	1.8	0.01	1.7	1.8	0.03
Dow Chemical	47.0	1.4	0.02	147.0	1.4	0.05	96.0	1.4	0.03
Ethyl	71.3	2.3	0.33	67.7	2.3	0.33	83.9	2.3	0.39
First Mississippi	13.4	1.5	0.23	5.2	1.5	0.09	20.8	1.5	0.30
Freeport-McMoRan	81.4	1.4	0.43	11.6	1.0	0.06	2.4	1.2	0.02
W. R. Grace	267.5	1.7	0.22	150.6	1.8	0.13	155.3	1.8	0.15
Monsanto	397.0	2.3	0.35	376.0	2.1	0.31	716.0	2.1	0.52
National Distillers	6.9	2.3	0.02	7.6	1.9	0.02	26.2	2.1	0.06
Pennwalt	68.2	2.1	0.31	52.4	2.0	0.25	82.0	2.1	0.40
Union Carbide	96.0	1.9	0.05	99.0	2.0	0.06	158.0	1.9	0.08
TOTAL	\$1852.5	1.8	0.18	\$1513.2	1.7	0.14	\$1965.1	1.7	0.19

Note: Current ratio is current assets divided by current liabilities. Cash ratio is cash and marketable securities divided by current liabilities.

SEPTEMBER 16, 1985

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BULK DRUGS
Production moves away from U.S.
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News of the Week

■ ACS meeting in Chicago draws more than 12,000 attendees. Page 4

■ Hydride ion fragments organochromium molecule into smaller-charged species. Page 5

■ Researchers at two Pennsylvania schools analyze blood sera of Bhopal victims. Page 5

■ Union Carbide revamps products and services groups. Page 5

■ ACS meeting goes on camera in the Windy City. Page 6

■ Nobel Laureate Paul J. Flory dead at age 75. Page 7

■ Soviet leader Gorbachev offers to honor chemical weapons-free zone in central Europe. Page 7

■ Richardson-Vicks says no to a Unilever takeover attempt. Page 8

■ Environmental groups, agricultural chemical industry agree on changes to pesticide law. Page 8

Cover: Chemical operator at Merck's Elkton, Va., plant telephones data from drying of a batch of thienamycin before transferring the antibiotic to the next stage of production.
Photo by Bob Day

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Editor's Page 3

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Business

Plastics intermediates production has fallen this year; as the general economy has slowed so have the markets for vinyl chloride, styrene, and toluene diisocyanate. Page 15

Government

Members of House committee criticize proposed reauthorization bill for Superfund; some claim it isn't strong enough, others score provisions such as that which pre-empts state standards. Page 23

Science

When Fermilab's 1-TeV colliding beam accelerator begins proton-antiproton collision experiments in 1986, it will be the highest energy accelerator in the world for particle research. Page 62

Isolation and characterization of a tunichrome, a bright yellow pigment found in blood of tunicates, may give a clue as to how the marine organism concentrates metals in its blood cells. Page 67



Product Report

Although the U.S. will consume a third of the medicinal drugs made this year worldwide, only a fourth will be manufactured in this country. Page 25

Production Slows For Plastics Intermediates

As growth in economy slackens and exports ease, demand declines for vinyl chloride, styrene, and toluene diisocyanate

Bruce F. Greek, C&EN Houston

Producers of vinyl chloride, styrene, and toluene diisocyanate (TDI) are having the year they reluctantly expected. Production of their end-use products, mainly various fabricated plastics and elastomeric items, will be down. Profits from making and selling the intermediates also likely will fall, even as prices for the two aromatic intermediates increase because of the rise in benzene prices.

The lowered production and profitability result from a maturing of the recovery after the recession. The general economy has slowed substantially in its growth, and this is reflected in housing and transportation, segments of the consumer products industry that require large shares of the production of these plastics intermediates.

Next year, minor improvement in demand for these intermediates has been forecast as a result of expected slight economic improvement. If this forecast proves to be accurate, production of the three major volume intermediates could return to the level of 1984, with the possible exception of TDI. Although production of TDI will recover somewhat, it will be hurt by increasing shifts toward another isocyanate—*p,p'*-methylene diphenyldiisocyanate (MDI)—which also is used in making polyurethanes. Export losses, however, could limit the production gains of these intermediates.

Longer term, the outlook for these plastics intermediates will mirror the recent past, reflecting quite closely economic conditions as they affect sales of autos, houses, furniture, packaging, and consumer disposables. Domestic consumption of these intermediates likely will trend higher as a function of the general growth in the gross national product.

However, production will not necessarily follow domestic consumption.

Key Chemicals

Exports of these intermediates have accounted for a significant part of their production, whereas imports have been small. Exports now are declining as a result of new plants coming on stream in various parts of the world. Imports, at least for styrene, are growing rapidly. The net change in exports over imports for all of these plastics intermediates could reduce production in spite of gains in domestic consumption.

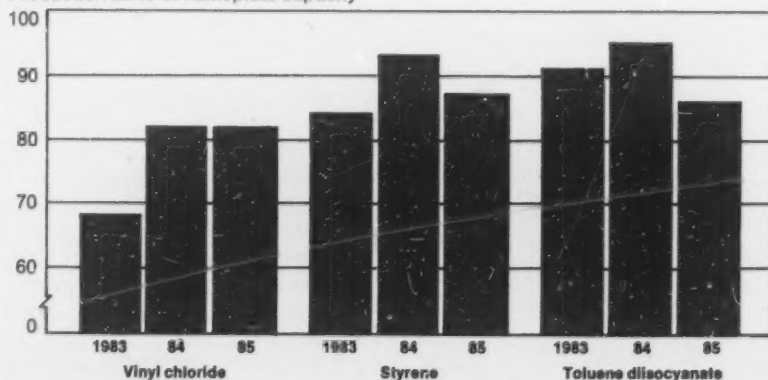
These changes in production, which are expected as a result of changes in foreign trade, cloud forecasts. For example, exports of these plastics intermediates, especially styrene, were expected to decline more this year than they have so far. Styrene exports held up early in 1985 because of startup difficulties at some of the new foreign plants. As these difficulties are overcome and as production nears a level needed to meet demands for their local consumption, foreign buying from U.S. sources will decline more.

Plant use could decline unless some of the presently operating capacity is shut down. Because some plants have been shut down for long periods and a few plants have been scrapped, a drop in capacity seems likely to occur if export markets keep declining. Consequently, the list of players in this scenario for styrene, TDI, and vinyl chloride will change by the end of this decade.

For details of the near-term outlook for styrene, TDI, and vinyl chloride, please see the following pages.

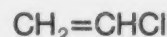
Plant utilization falls in 1985

Production as % of nameplate capacity



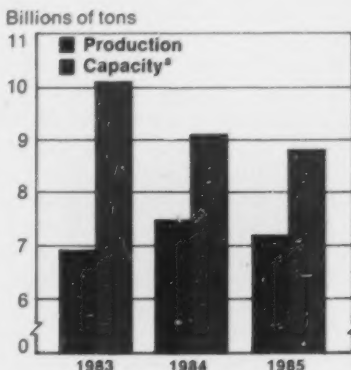
Sources: International Trade Commission, C&EN estimates

Vinyl Chloride



- Demand down
- Capacity lower
- Prices weak

PRODUCTION/CAPACITY



a First quarter; includes some shut-down capacity.

MAJOR PRODUCERS

Dow Chemical, Formosa Plastics, Georgia-Gulf, B. F. Goodrich, PPG Industries

HOW MADE

Dehydrochlorination of ethylene dichloride made by reacting chlorine with ethylene

MAJOR DERIVATIVES (U.S.)

Vinyl polymers nearly 100%

MAJOR END USES (U.S.)

Fabricated plastic items nearly 100%

FOREIGN TRADE

Exports—declining to 1 billion lb in 1985, imports—rising to more than 150 million lb in 1985

PRICES

21 cents per lb

Vinyl chloride producers are facing declines in demand and price, and their success in dealing with these problems may well determine the future health of the vinyl chloride business.

Forecasts of production of vinyl chloride in 1985 group at around 7.2 billion lb. Production in 1984 was slightly more than 7.5 billion lb. Some optimistic estimates of 1985 production are as much as 7.4 billion lb, but that is still below 1984 output. Pessimistic estimates now call for production to be down 10% in 1985 to about 6.7 billion lb.

The pessimistic forecast stems from the fact that, though first-quarter production of the monomer was high (as it historically is) because of strong demand for polyvinyl chloride pipe used in construction, pipe demand now is down and pipe producers and consumers are reducing their inventories, much as they did in third-quarter 1984. Vinyl chloride producers also know that pipe demand slumps in the third quarter, and they are reducing production accordingly.

Some industry observers believe second-quarter production of vinyl chloride fell to an annualized rate of 6.4 billion to 6.6 billion lb, and that third-quarter output will slow to 6 billion lb a year. A pickup in the fourth quarter, following historical trends, could bounce the production level back to about a 7 billion lb-a-year rate. Such a pickup might be even larger if a predicted strong increase in housing construction occurs in 1986.

Producers of vinyl chloride still face substantial overcapacity, even though some capacity was scrapped in the early 1980s. Currently some of the 8.8 billion lb of nameplate capacity is shut down. The practical operating capacity now may be about 8 billion lb per year, possibly less for all of 1985 because some producers have been making leisurely turnarounds of their plants.

If the total operating capacity for

1985 averages 8 billion lb, and total production reaches 7.2 billion lb, then the average operating rate for vinyl chloride will be a respectable 90%. However, if actual production amounts to close to the 6.7 billion lb level, the rate becomes a less-than-satisfactory 84%.

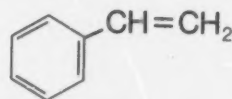
Currently, operating rates are lower than the estimated annual rate, and overcapacity is causing dire problems for vinyl chloride pricing. The list price for vinyl chloride is 28 cents a lb, less a 25% temporary voluntary allowance of 7 cents. But actual selling prices are about 18 cents a lb, possibly less. Some cost relief is afforded by the current low price for feedstock ethylene, about 14 cents a lb. Unfortunately, less than half of the vinyl chloride molecule is ethylene. Chlorine, 57% of the molecule, has firmed in price recently, but electrolysis plant operating rates are down from the past winter. Vinyl chloride consumes about 40% of chlorine production.

Almost all vinyl chloride is polymerized. U.S. sales and captive use of polyvinyl chloride (PVC) and of copolymers declined 3.7% in the first half of 1985 compared with first-half 1984, according to the Society of the Plastics Industry's Committee on Resin Statistics. The decline is less for pipe uses, which account for 45% of PVC consumption, at 2.1%. None of the other end uses of PVC take much more than 10% and most are smaller.

Several unsuccessful attempts have been made this year to raise PVC selling prices. Any increases in PVC prices should quickly come back to the monomer producers and help their low or absent profitability.

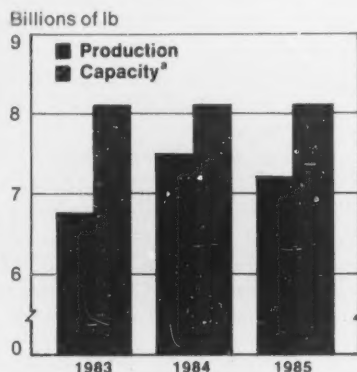
Exports of vinyl chloride give producers another problem. Because of the usual export deterrents—the strong dollar and new foreign capacity—exports of vinyl chloride could decline as much as 200 million lb in 1985 to less than 900 million lb. Imports may rise as much as 50 million lb, for a loss in net exports of nearly 25%.

Styrene



- **Demand down**
- **Capacity expanded**
- **Prices higher**

PRODUCTION/CAPACITY



* First quarter; includes some capacity not operating.

MAJOR PRODUCERS

American Hoechst, Arco Chemicals, Cosmar, Dow Chemical, Monsanto

HOW MADE

Dehydrogenation of ethylbenzene; coproduction with propylene oxide

MAJOR DERIVATIVES (U.S.)

Polystyrene 60%, styrene-butadiene rubbers and latices 15%

MAJOR END USES (U.S.)

Fabricated plastics and rubber products almost 100%

FOREIGN TRADE

Exports—falling below 1 billion lb in 1985, imports—rising to more than 150 million lb in 1985

PRICES

26 to 30 cents per lb

Many of the changes occurring in the U.S. styrene industry have been forecast during the past two years. However, others have not. Small producers, expected to leave the business because of chronic overcapacity, have continued to operate. Conversely, one large producer, American Hoechst, will sell its plants. Exports, expected to decline radically, are declining slowly and behind schedule.

The sale of American Hoechst's styrene operations to Huntsman Chemical will not necessarily reduce industry capacity to make styrene. Because the sale is scheduled to be completed at the end of this month, plans for any changes in operation of the acquired plants haven't yet been announced by Huntsman. Included in the agreement are a 1 billion lb-a-year styrene plant at Bayport, Tex., and two polystyrene plants, at Chesapeake, Va., and Peru, Ind., with a combined capacity of 500 million lb a year.

Styrene capacity has risen during 1985. In May, formal dedication ceremonies were held by Cosmar, a joint venture of Cosden Oil & Chemical (a subsidiary of American Petrofina) and Borg-Warner Chemicals, to mark the conclusion of an expansion of its plant at Carville, La., by 200 million lb to 1.5 billion lb annually. This addition brings U.S. capacity to about 8.3 billion lb a year. Another 750 million lb of currently idle capacity could become available, although most of it has been shut down for more than two years, making future operation unlikely. Further debottlenecking could add a small amount of capacity to the 8.3 billion lb. Debottlenecking, however, likely will be below normal this year because of the low profitability that producers have faced for some time.

The average operating rate in 1985 is difficult to estimate because demand could change later this year. As 1985 began, production was running about 9% below the 1984 rate, according to International Trade Commission (ITC) estimates. Industry

sources report that output improved during the second quarter, but may have slowed again in this quarter. For the whole year, estimates of styrene production cluster around 7.2 billion lb, down less than 4% from production in 1984, which was estimated at 7.5 billion lb.

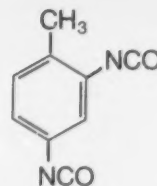
Estimates of the decline in styrene output for 1985 range between none and 8%, putting production between 7.5 billion and 6.9 billion lb. If the Cosmar expansion in capacity is available for nine months of 1985, and other minor additions are available, then operable nameplate capacity likely will total 8.3 billion lb for the whole year. Therefore, the average operating rate will range from 83 to 90% of nameplate capacity.

The biggest factor in the range of estimates for styrene production during 1985 will be the net of exports less imports. Exports of styrene in 1984 were nearly 1.2 billion lb, or 16% of production. Imports were much more modest at just over 100 million lb. Exports in 1985 may decline 25% to under 900 million lb, and imports may rise by half to more than 150 million lb. The net of exports then would fall to 750 million lb, down about a third. However, if new capacity coming on stream in other countries operates more reliably than it has so far, and the strength of the dollar holds up, U.S. exports of styrene could fall more than anticipated and imports also might rise more than anticipated. The result could be that production will be 7.0 billion lb or lower in 1985.

Styrene producers can get little help from the major uses of polymer material. Polystyrene production increased during early 1985, but the month-to-month gains now are smaller. Other uses also have met with production declines. With small growth forecast for the economy during the second half of 1985, gains in demand for consumer products containing styrene will not offset a greater than expected decline in the net of exports less imports.

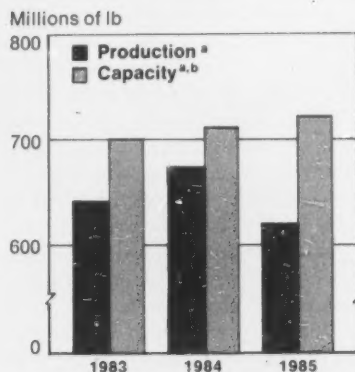
Key Chemicals

Toluene Diisocyanate



- **Demand weakening**
- **Capacity up slightly**
- **Price discounted**

PRODUCTION/CAPACITY



^a Mainly 80/20% mixtures of 2, 4- and 2, 6-isomers.
^b First quarter; includes some capacity not operating in 1985.

MAJOR PRODUCERS

BASF Wyandotte, Dow Chemical,
Mobay Chemical, Olin,
Rubicon Chemicals

HOW MADE

Nitration of toluene, followed by reduction to diamine, reaction with phosgene, purification, and recovery of coproduct hydrochloric acid

MAJOR DERIVATIVES (U.S.)

Polyurethanes almost 100%

MAJOR END USES (U.S.)

Flexible polyurethane foams 85%,
polyurethane coatings 5%

FOREIGN TRADE

Exports—declining slightly to about 135 million lb in 1985,
imports—negligible

PRICES

93 cents a lb

Like that for other major-volume polymer materials, demand for toluene diisocyanate (TDI) is declining as demand for products containing the polymers made from this plastics intermediate wanes. Whether a recovery will occur late in 1985 is debatable.

The decline in production of TDI in 1985 from last year's almost 675 million lb could be greater than current forecasts of about 8%, for a 1985 production total of about 620 million lb. After a good first quarter with output at an annual rate of more than 640 million lb, second-quarter production fell to well under a 600 million lb-per-year rate. During the third quarter, production has not risen appreciably, according to some industry sources, but the third quarter historically is the low one for TDI production.

A pickup in TDI production often occurs in the fourth quarter, raising hopes for total 1985 production of close to 620 million lb or possibly higher. To have a significantly higher total production for 1985, a shutdown plant may have to be restarted early enough to provide additional output during the fourth quarter. If the fourth-quarter pickup fails to develop, then the total for 1985 could be down almost 10% from 1984 to about 610 million lb. If TDI production falls to this level, it would be less than that for 1983 when production was recovering well from the recession.

Total TDI nameplate capacity is 720 million lb, but this includes an 80 million lb-a-year plant that Olin shut down almost a year ago for an indefinite period. Therefore, TDI operating capacity now is 640 million lb a year. To reach an annual production of 620 million lb in 1985 without the Olin plant, all of the remaining capacity would have to be run at an average of 97% of nameplate capacity. Debottlenecking could increase capacity another 5% or so this year, or some 30 million lb. Such added capacity, however, can't be counted on throughout the year. If production does amount to

610 million lb, operating plants will average a rate of 95% of nameplate capacity at the beginning of 1985. These high operating rates could strain plants and further spur debottlenecking efforts.

The drop in TDI production this year will result from several factors. One is a slowly continuing decline in exports of TDI. Exports in 1985 may total 135 million lb, but they could be as low as 120 million lb, down about 10% from 1984 exports.

Another is a falloff in demand for the major end uses of flexible polyurethane foams, such as furniture (including bedding and carpet underlay) and automobiles, buses, and trucks. The furniture uses of polyurethane foams are strongly influenced by housing construction. During the late spring and early summer, housing construction trended downward, reducing the potential for furniture sales later this year. Other than building of inventory by furniture manufacturers and retailers, demand for polyurethanes, and in turn TDI, will be lackluster.

The bedding area for polyurethane foam also faces severe competition and may not return to the demand levels of the early 1980s for several more years. A major part of the demand problem in bedding is the success in sales of waterbeds. One industry source estimates that waterbeds now account for 15% of mattress sales, cutting into the market for foams, which has been growing very slowly. Waterbed demand will continue to grow, reducing urethane foam consumption for bedding.

Automotive uses of flexible polyurethane foams are extensive, but these are dominated by seating. Most seating now is molded of a fire-retardant foam. Because of the downsizing of cars, consumption of foam per car is more than 10% lower than it was five years ago. Prospects for growth in automotive uses are better than in other major end uses, but they still are quite small relative to past growth.

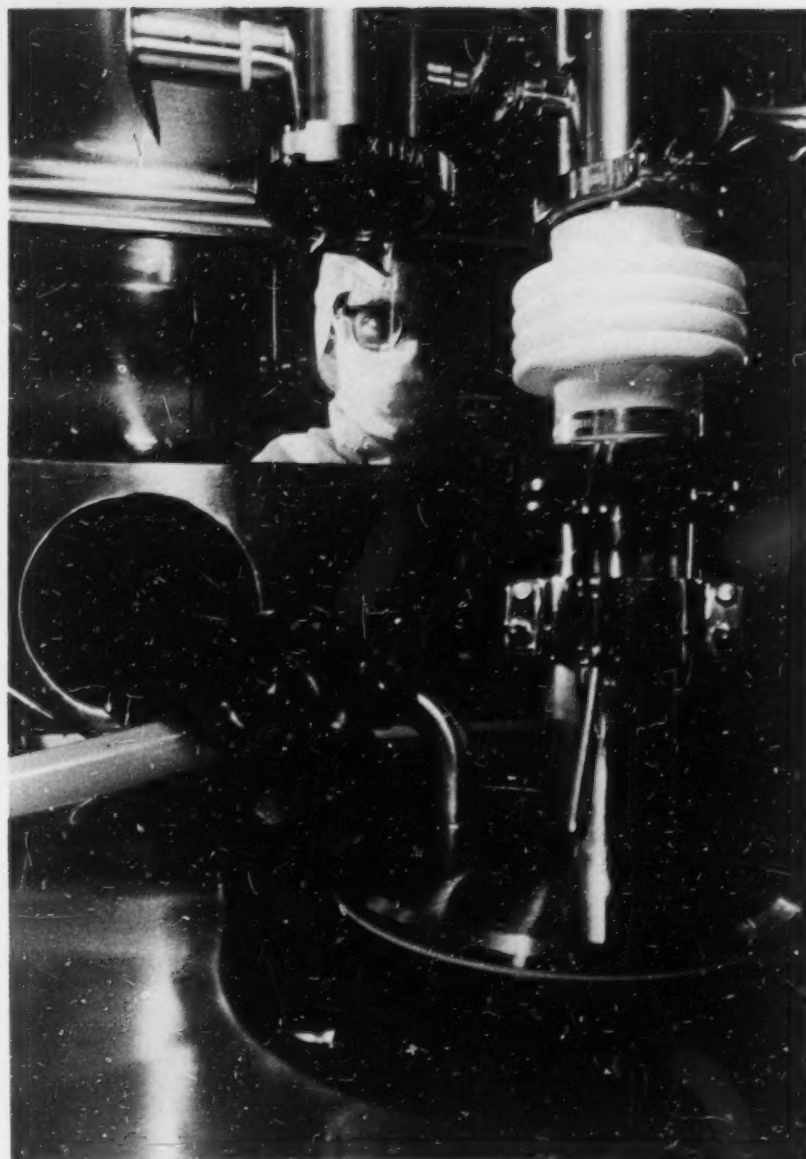
Bulk Drug Output Moves Outside U.S.

Stephen C. Stinson, C&EN New York

World production of bulk drugs for human medicine will hit 530 million lb in 1985, worth \$7.9 billion. This volume represents a 4% rise over the 510 million lb produced in 1984. The value is 6% greater than the \$7.4 billion of last year. These figures for bulk medicinal chemicals bear no relation to the volumes or manufacturers' values of finished dosage forms or to the eventual retail value of dosage forms. The figures also do not include medicinal chemicals for veterinary, agricultural, or nonmedical uses.

Of the 530 million lb to be produced worldwide this year, only one quarter or 140 million lb will be made in the U.S., although this country will consume one third or 180 million lb of that. This excess of domestic consumption over production continues a long-term trend of decisions, even by American discovery and generic drug firms, to have bulk compounds made outside the U.S.

Western European firms will make 35% or 185 million lb. Countries in



Merck worker fills special sterile stainless steel containers with thienamycin antibiotic for shipment to other Merck plants for finishing into dosage forms

Western Europe will consume 32% or 170 million lb. Japanese firms will produce 8% or 45 million lb, and Japan's own pharmaceutical industry will use 4% or 22 million lb. Producers such as those in China and Eastern European countries will make 30% or 160 million lb. All of these countries besides the U.S., Japan, and those of Western Europe will also consume 160 million lb.

Some of the distinctive patterns of drug consumption in different countries have been detailed by Peter Hall of SRI International, Menlo Park, Calif. Hall has studied the bulk medicinal chemical industry as an analyst in SRI's specialty chemical

research program. He notes that the Japanese have a relatively high per capita consumption of antibiotics and anticancer drugs. The French lead in consumption of cerebral vasodilator drugs. Use of cardioglycosides for heart disease is high in West Germany.

Hall has characterized the drugs consumed in the largest volumes throughout the world. He notes that 18 bulk medicinals comprise 82% of the volume consumed annually and 40% of the dollar value. These include ascorbic acid (vitamin C, 66 million lb), aspirin (56 million lb), and acetaminophen (31 million lb).

Such bulk drugs tend to be com-

Drug plants need exacting specifications

The changing U.S. climate in drug production and marketing leads to continual building of new plants everywhere in the world. To meet their new plant needs, makers of bulk medicinals and dosage forms call on such companies as Catalytic, Crawford & Russell, and Foster Wheeler, that have special expertise in designing and building pharmaceutical plants. Integrated, multinational drug firms maintain their own engineering and construction divisions. But even these firms contract outside their company when their own divisions are strained to capacity.

One of the largest sellers of engineering and construction services to the drug industry is Foster Wheeler. The Livingston, N.J., company currently has pharmaceutical projects under way worldwide with a total installed cost of almost \$800 million. These range from relatively small plants costing several hundred thousand dollars to large plants with price tags of more than \$50 million. Foster Wheeler engineers furnish services ranging from site selection and feasibility studies to plant design and materials procurement to plant erection and performance guarantees.

To Tele Gnudi, Foster Wheeler's technical director for pharmaceuticals and fine chemicals, each plant type has its own leading design theme. For production of dosage forms, the theme is product integrity. For organic synthesis of bulk medicinals, the issue is product purity. Sterility is the guiding principle for fermentation plants.

In addition, Gnudi says, Foster Wheeler engineers conceive dosage form plants from the beginning with a view to eventual inspection by the U.S. Food & Drug Administration for adherence to the agency's guidelines for Current Good Manufacturing Practices (CGMP). FDA inspectors resident

in other countries also visit plants that will export to the U.S. The agency has not yet applied CGMP to plants that make bulk medicinals. But that future possibility leads Foster Wheeler to design compliance into the product purification sections of such plants. Thus the engineering firm confers with FDA inspectors and outside consultants at the outset of a project.

To ensure product integrity in a tableting plant, for example, Gnudi and his colleagues locate production of different tablets in different rooms. Each room may need its own filtered air supply, which is scrubbed before venting. The Foster Wheeler team specifies room interiors for ease of cleaning, especially the cleaning that accompanies product or machinery changeovers. It studies movements of workers and products, and locates air locks, showers, and locker and uniform rooms with a view to preventing cross-contamination. Some products may need unidirectional personnel paths, in which workers never retrace their steps.

All these measures influence costs of energy management and capital investment. Foster Wheeler engineers study different layouts and schemes of energy management and consult with the client on these implications of the original specification. Another consideration is the "just-in-time" concept of production, in which each component of the packaged dosage form appears at the moment of need to minimize inventories.

In addition to product purity, waste treatment and worker safety are important to synthetic organic bulk medicinal plant design, Gnudi says. Environmental problems are often not so severe as with other fine chemicals plants, because amounts produced are

relatively smaller. The plant can sell waste solvents to a scavenger, for example, rather than recover them. But needs for product documentation are greater than for other plant types. Managers must be able to trace a batch in detail.

Sterility is the main issue in fermentation plants, Gnudi points out, because the operator may carry out only 40 fermentations in a fermentor per year. Spoiling one batch by contaminating organisms may result in loss of a product costing \$1500 per kg. But worker safety is also important in such plants. Their products can be potent allergens, and exposure may bring severe reactions. Waste treatment is also a factor. Spent broths contain nutrients whose degradation by microorganisms would deplete oxygen in lakes and streams. Sludge must be incinerated or disposed of safely in a landfill.

With all of these details to include in the final design, Gnudi says that Foster Wheeler often gets tantalizingly little information from a potential client about the type of plant desired. Because of drug companies' desires for secrecy, the initial specification may be only that the plant is expected to cost "\$10 million to \$80 million," contain "30 to 60 reactors of various capacities," and be capable of such special reactions as hydrogenation.

At this stage, Gnudi says, the client contacts many engineering companies to see what experience they have with the plant type, what chemical engineering capabilities they have, and whether they will have the manpower available during the time the plant is to go up. As the list of engineering companies being considered narrows, Foster Wheeler receives increasing information about what the plant is expected to do.

modities with little captive consumption, resulting in a large open market. None of them have much patent protection left. High percentages of them have nonmedicinal uses. For example, although they comprise 82% of bulk medicinals consumed, these compounds amount to only 53% of consumption for medical and dietary use.

Despite their commodity status, the sheer volumes of these bulk drugs lead to high total market values. Two thirds of them have sales of more than \$50 million per year. These compounds also tend to have relatively high consumption outside of developed countries.

In contrast to the high-volume bulk medicinals, however, a few

well-known drugs have worldwide consumptions measured in hundreds of pounds. Use of the anticancer drug methotrexate is only 360 lb. Consumption of the antihypertensive agent clonidine amounts to 300 lb.

Hall also has identified some of the factors that make for success in producing bulk medicinal chemi-

Product Report

cals. One factor is captive use for the compounds, which is characteristic of makers of over-the-counter drugs and dosage forms of prescription drugs. On rare occasions after their patents on certain compounds have expired, drug firms will sell bulk compounds to competitors.

A second factor Hall cites is possession of unique chemical processes that competitors are unable or unwilling to undertake. Many drug companies are unwilling to carry out nitrations, for example, because there is constant risk that these reactions will run out of control. Production of organofluorine compounds, reactions at cryogenic temperatures, and fermentative production of steroids and antibiotics are technologies that potential customers may lack.

A third factor for success is sales to countries with little or no patent protection. For example, many developing countries refuse to honor drug patents. And Canadian law

compels drug companies to license their patents.

The reasons for the long-term gravitation of bulk drug production away from the U.S. are economic, environmental, and technological. First, production costs in other countries tend to be much lower. Another economic factor is that countries like Italy, Hungary, Poland, and China historically have targeted the

bulk drug industry as a source of foreign exchange. Even if some of these overseas producers have since abandoned subsidized pricing and disregard of drug patents as marketing tools, their aggressive entries into the bulk drug market have made them formidable competitors.

A case in point is Italy. At the close of World War II, the government allowed Italian companies to

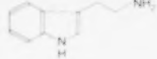
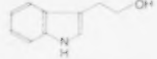
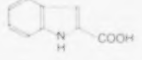
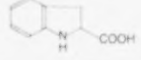
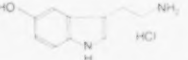
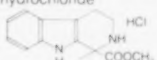
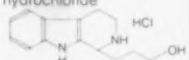
Volumes of bulk drugs consumed differ by world regions

Millions of lb	U.S.	Western Europe	Japan	Other	Total
Antibiotics	19.4	24.5	4.4	15.1	63.4
Anti-infectives & antiparasitics	6.6	21.1	0.9	42.3	70.9
Cardiovascular agents	1.4	2.3	0.4	2.3	6.4
Central nervous system agents	66.8	40.0	3.3	41.1	151.2
Respiratory agents	3.2	4.0	0.9	2.9	11.0
Steroids	0.1	0.1	a	0.1	0.3
Vitamins	59.0	53.8	9.3	38.1	160.2
Other	2.5	2.9	0.3	1.8	7.5
TOTAL	159.0	148.7	19.5	143.7	470.9

Note: Data for 1982. a About 15,000 lb. Source: SRI International

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1,2,3,4-Tetrahydroquinoline 	5,6,7,8-Tetrahydroquinoline 	Decahydroquinoline 
1,2,3,4-Tetrahydroisoquinoline 	5,6,7,8-Tetrahydroisoquinoline 	Decahydroisoquinoline 

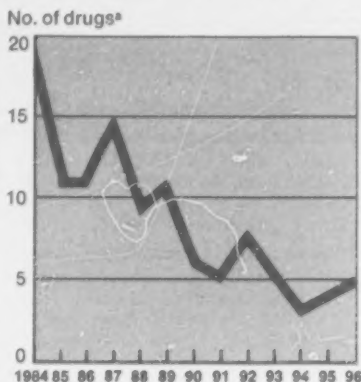
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Number of drugs coming off patent set to decline



a Includes allowance for drugs granted 10-year exclusivity under Waxman-Hatch Act.

ignore drug patents in developing their own production. At first, Italian firms simply copied the products and processes of others. These companies graduated to improving chemical processes. Today, the Ital-

ian industry has become highly innovative, to which the growing number of anticancer drugs from that country attests. As a member of the European Economic Community, the Italian government has adopted respect for the drug patents of others. But their early technological and new drug discovery capabilities have multiplied the number of Italian bulk drug firms and made them prime candidates to supply the growing U.S. generic drug industry.

Today there are 70 Italian companies that make bulk medicinal chemicals on a consistent basis, says SRI's Hall. Their annual output is worth about \$1 billion, 80% of which they export. These Italian firms supply about 50% of the needs of U.S. generic drug companies.

Again, authorities in other countries are often more comfortable with environmental and safety risks of bulk drug production than those in the U.S. Medicinal chemistry can

involve nitrations and use of phosgene. Whereas many American firms large and small routinely carry out such reactions safely, it is difficult to gain approval for a new plant.

The early targeting of the bulk drug industry by producers in other countries has given them technological advantages in the making of certain compounds. The making of any one bulk medicinal is a unique problem, itself, so experience carries much weight. Foreign producers also get technological head starts from the expiration of drug patents in other countries sooner than in the U.S. The Canadian compulsory drug patent licensing law also makes it easier for producers there to gain expertise. Even if they cannot yet supply the patent-protected U.S. market for certain compounds, such firms can become the cost-effective producers by the time each patent runs out here.

All of these factors show up in one decision on how to secure a

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Product Report



Merck Sharp & Dohme technician prepares blood plasma for hepatitis B vaccine

supply of propranolol for the U.S. generic market. The U.S. patent on propranolol, a best-selling drug (more than \$300 million in the U.S. last year) to treat hypertension and heart disease, ran out in 1984. Until then, Ayerst Laboratories division of American Home Products Corp. was alone in marketing its Inderal brand of propranolol here. Lederle Laboratories division of American Cyanamid Co., Chelsea Laboratories, and Martec Pharmaceuticals filed for Food & Drug Administration approval to market generic forms of the drug.

As Martec vice president for operations Udo Vetter explains, there were only three makers of bulk propranolol in the world who had FDA-inspected plants and who had filed Drug Master Files on propranolol with FDA. A Drug Master File includes details of chemical reactions, processes, and raw materials used to make a drug.

The three eligible propranolol producers were the U.K.'s Imperial Chemical Industries (ICI), which had licensed its patent to and supplied Ayerst, Industrie Chimiche Italiane (Ici), and Cosma of Bergamo, Italy. The experience of the Italian firms stemmed from their production for countries in Western Europe, where the patent had expired earlier, and in developing countries, which often ignore drug patents.

Licensing agreements with Ayerst prevented ICI from supplying Mar-

tec. Ici had already agreed to supply Lederle, and Martec managers felt that Ici's plant capacity might be unequal to two customers' needs. Cosma offered the additional attraction of a plant dedicated to few products, thus minimizing risks of cross-contamination. To receive FDA qualification to export bulk medications to the U.S., Cosma had to have a North American representative, which is ACIC of Toronto, Ont. As North American representative, ACIC holds the Drug Master File for propranolol, follows U.S. regulatory affairs for Cosma, and acts as importer of propranolol.

Vetter explains that as a fledgling marketer of pharmaceuticals in dosage form, Martec could not afford any mistakes with such an important drug. Thus as it became apparent that the Lederle and Chelsea generic products would be approved soon, Martec opened negotiations with a number of well-regarded generic drug houses. The firm reached a marketing agreement with Zenith Laboratories.

Cosma now produces bulk propranolol in Bergamo, and ACIC imports it into the U.S. for delivery to Martec. After Martec chemists do quality control testing on each batch, it is delivered to Schering Corp. Schering does its own testing as it receives each batch, formulates the bulk compound into tablets of 10, 20, 40, and 80 mg, bottles them, and applies the Zenith label to each bot-

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GENETIC CHEMISTRY: THE MOLECULAR BASIS OF HEREDITY**

November 4-6, 1985

The Shamrock Hilton Hotel, Houston, Texas

PROGRAM

Paul Berg, Presiding Scientific Advisory Board Member

Monday, November 4, 1985

- 9:00 **JACK S. JOSEY**, President, Welcoming of Guests.
9:05 Introductory Remarks.
CONFIRMATION ISOMERS OF THE DNA DOUBLE HELIX
9:20 **ALEX RICH**
10:00 **RICHARD DICKERSON**
10:40 Discussion
TOPOLOGICAL ISOMERS OF THE DNA DOUBLE HELIX
11:05 **JAMES C. WANG**
11:55 Discussion to be led by **NICHOLAS R. COZZARELLI**
THE PACKAGING OF DNA IN CHROMOSOMES
1:30 **AARON KLUG**
2:30 Discussion to be led by **ABRAHAM WORCEL**
PROTEIN-RNA INTERACTIONS
3:15 **PETER B. MOORE**
4:05 Discussion to be led by **PAUL SCHIMMEL**

Tuesday, November 5, 1985

- DNA AND CHROMOSOME REPLICATION**
9:00 **ARTHUR KORNBERG**
9:50 Discussion to be led by **BRUCE M. ALBERTS**
RECOMBINATION OF DNA
10:45 **CHARLES M. RADDING**
11:35 Discussion to be led by **HOWARD A. NASH**
12:15 Lunch
1:00 **DUILIO ARIGONI, 1985 WELCH AWARDEE**
THE TRANSCRIPTIONAL UNIT OF DNA EXPRESSION
2:15 **JAMES E. DARNELL**
3:00 **MICHAEL J. CHAMBERLIN**
SPLICING OF RNA
3:55 **THOMAS R. CECI**
4:30 **THOMAS MANIATIS**
5:15 Discussion to be led by **PAUL BERG**

Wednesday, November 6, 1985

- CHEMICAL SYNTHESIS OF DNA**
9:00 **KEIICHI ITAKURA**
9:40 **MARVIN H. CARUTHERS**
10:40 **MICHAEL SMITH**
11:20 Discussion to be led by **ROBERT LETSINGER**

REGISTRATION FORM

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October 15, 1985**

Product Report

tle. Martec maintains its own employee in Schering's Kenilworth, N.J., plant, who oversees formulation and tableting according to Martec's specified process. Martec's representative recommends each batch of tablets for approval and Schering ships it to Zenith. Acting for Martec, Vetter officially releases each shipment while it is on its way to Zenith. As a large-volume marketer of generic pharmaceuticals, Zenith sells the generic propranolol to such outlets as drugstore chains and other firms that distribute to low-volume users like independent pharmacies. Under its agreement with Zenith, Martec retains the right to sell to hospitals, though Vetter points out that this is not a very important market for propranolol.

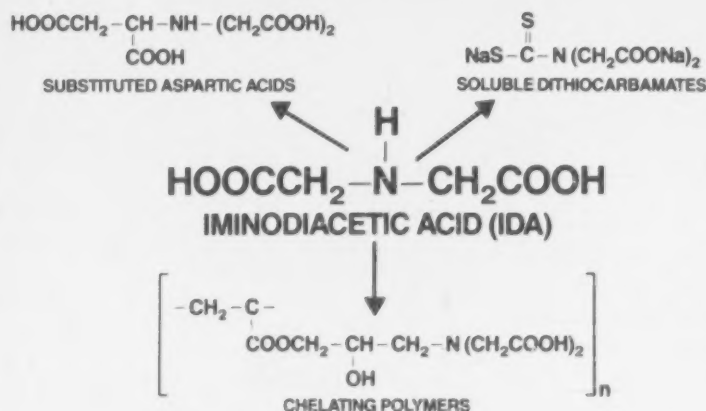
Companies like ACIC are important intermediaries for arranging supplies of bulk drugs for U.S. firms. ACIC represents eight other producers in the burgeoning Italian industry as well as more companies in other countries. But in a turnabout of the historic trend of production moving abroad, ACIC has opened a bulk drug plant in Richmond, Calif., and will start up another in Brantford, Ont., in the beginning of 1986.

The Richmond plant will make chlorpromazine, a major tranquilizer to treat psychosis, and methyl-dopa, used for hypertension. ACIC's executive vice president Luciano Calenti says, "We feel that the total growth of the market means opportunity in the U.S., if done on the right scale and in the proper way. We can be cost competitive." Calenti adds that a possible fall in the value of the dollar may increase the competitiveness of the California plant.

Calenti says that ACIC has not yet decided on the product slate for the Brantford plant. Products will be chosen according to opportunities under Canada's compulsory drug patent licensing law and in developing countries that do not accept validity of drug patents at all.

Speaking of countries active in selling bulk drugs worldwide, Peter Hall of SRI International says, "Bulk medicinal chemicals supplied by companies in Eastern Europe and

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Product Report

Eighteen drugs account for 82% of volume consumed

Compound ^a	Value (\$ millions)	Consumption (millions of lb)	
		Medicinal	Total
Ascorbic acid	\$ 325	36.4	66.1
Penicillin G	240	4.2	18.3
Vitamin E	230	7.2	14.3
Ampicillin	150	3.7	3.7
Aspirin	115	55.6	55.6
Acetaminophen	100	31.3	31.3
Penicillin V	100	1.5	6.8
Riboflavin	90	1.8	4.7
Sulfonamides	90	8.0	11.0
Thiamine	85	3.6	5.5
Niacin & derivatives	65	4.8	19.4
Calcium pantothenate	60	1.8	8.8
Caffeine ^b	45	4.4	9.9
Chlortetracycline	40	0.3	2.5
Pyridoxine	40	2.1	2.6
Tetracycline	35	0.8	2.9
Oxymetazoline	30	1.6	2.6
Theophylline	15	3.0	3.0
TOTAL	\$1855	172.1	289.0

^a Data for U.S., Western Europe, and Japan only. ^b Synthetic only. Source: SRI International

China for world markets are small compared with other regions, but production is growing rapidly and is particularly significant in terms of price competition with Western Europe and the U.S."

In the U.S., China is represented by Sinochem in New York City. Hall calls China an important supplier of acetaminophen analgesic, broad-spectrum antibiotic chloramphenicol, and diosgenin, which is a plant-derived steroid that can be converted to such steroid drugs as betamethasone and dexamethasone.

Medimpex North America, New York City, represents firms in the Hungarian pharmaceutical industry, which has a long history. Perhaps the oldest is Chemical Works of Gedeon Richter, which started in 1901 by extracting drugs from plants. Richter products include cardiac glycosides, steroids, ergot alkaloids, anticancer drugs related to vinblastine, and synthetic organic chemical drugs. Chinoin Pharmaceutical & Chemical Works began by extracting codeine and morphine alkaloids from poppy straw and seed and making B vitamins by fermentation. Most of Chinoin's current products are synthetic organics, and most of the Hungarian alkaloid business is handled by Alkaloida Chem-

Double-barreled law may boost bulk drug sales worldwide

A new law passed by Congress late last year indirectly may increase the number of bulk medicinal chemicals produced, raise worldwide levels of production, and shift production sites geographically. These effects could result because competition from generics has forced discovery companies to redouble their research efforts to find new, patent-protected compounds. To sustain their growth, generics houses have had to begin their own pioneering research to survive an expected crunch in the 1990s. Their research also will increase the number of new compounds. Intensified work on new, patent-protected dosage forms and drug delivery systems may prolong life cycles of old compounds, sustaining their production in bulk. Lower prices for generics could increase worldwide demand, leading to higher production of bulk compounds. These changes in demand for bulk medicinals could either accelerate the shift

of production away from the U.S. to Europe and the Far East, or they could tempt U.S. firms to reassert this country's leadership in drug manufacture.

The Drug Price Competition & Patent Term Restoration Act of 1984 was the brainchild of Rep. Henry A. Waxman (D.-Calif.) and Sen. Orrin G. Hatch (R.-Utah). It both eases Food & Drug Administration approval of generic forms of off-patent drugs and extends patent lives of drugs by amounts of excessive time spent in gaining FDA approval. Congress passed the law a year ago, and it became effective last November.

To gain FDA approval, the generic marketer now files an Abbreviated New Drug Application (ANDA). The medical use, ingredients, strength, labeling information, and dosage form must be the same as those approved for the original, brandname drug. The generic marketer also must file results of tests showing that the generic form is bioequivalent

to the original drug. A Drug Master File (DMF), which includes details of synthesis, raw materials, and names of producers of intermediates and bulk drug, also must be submitted. Generic marketers may now use the drug to do bioequivalency tests and develop the DMF before the patent expires without being accused of violating the patent.

There are some exceptions to ease the transition for brandname drug firms. For example, an ANDA may not be granted for 10 years for new chemical entities approved for the brandname firm between Jan. 1, 1982, and Sept. 24, 1984. Thus the patent on Pfizer's Feldene brand of piroxicam anti-inflammatory expires in 1988, but no ANDA will be granted before 1992, because FDA approved Pfizer's New Drug Application (NDA) in 1982. Also, no ANDA may be granted for two years for drugs or formulations whose supplemental NDAs were approved between Jan. 1, 1982,

METALLATION

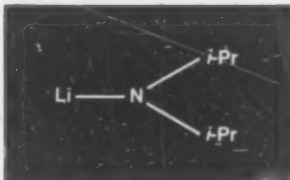
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ical Factory. Other Hungarian bulk drug firms are Biogal Pharmaceutical Works and Egis Pharmaceuticals.

Any firm hoping to export bulk drugs to the U.S. must have its plant inspected by FDA for adherence to the agency's Current Good Manufacturing Practices. FDA does not maintain resident inspectors outside the U.S. Rather inspectors knowledgeable in plants of a certain type make 30-day tours to particular regions of the world to see plants of that type. Tours have included Eastern Europe and China. In addition, FDA recognizes plant approvals by Canadian, Swedish, and Swiss inspectors in those countries.

Perhaps the biggest factor affecting U.S. production and marketing of bulk medicinal chemicals has been the passage of the Drug Price Competition & Patent Term Restoration Act of 1984. This law has the potential to increase world levels of bulk drug production, reverse the flow of bulk drug production away from the U.S., or to accelerate that flow. The law took effect only in November 1984, so it is too soon to judge the net effects it will have.

One section of the law makes it easier for firms to gain FDA ap-

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and Sept. 24, 1984. Thus all present tablet strengths of generic propranolol for heart disease and hypertension may be approved now except 80 mg, which must wait until mid-1986.

To gain an extension of a patent, the patent holder applies to the Patent & Trademark Office. The patent office asks FDA to verify the amount of time the drug spent in regulatory review and publishes the proposed extension in the *Federal Register*. Challengers have 180 days to argue that the applicant itself caused delays by failing to be diligent. To be eligible, the patent must still be in force; may cover a compound, use, or production process; and can be extended only once. The extension is limited to half the time the drug spent as an Investigational New Drug at FDA. It cannot exceed five years. And the sum of the patent life after NDA approval and the extension cannot exceed 14 years.

There have been delays in implementing Waxman-Hatch owing to the flood of paperwork, lack of sufficient

staff in the offices involved, and defects in filings. About 600 ANDAs have been filed by generic marketers in the past 10 months. The first approval came on Feb. 1, 1985, for Biocraft Laboratories to market disopyramide for abnormal heart rhythms. FDA officials say that the Division of Generic Drugs is now fully staffed, and that the backlog began to break loose in midsummer. There have been a total of seven major generic drugs approved this year. The latest is diazepam, the generic form of the popular tranquilizer Valium (C&EN, Sept. 9, page 5).

The patent office has received 28 applications for patent extension, of which it denied 16. Ironically, the first approval was for a nuclear magnetic resonance scanner, whose wait for patent extension may be granted in October. The first company whose drug patent may be extended is Pharmacia of Sweden, which may get 473 more days' protection for its Promit brand of injectable dextran solution on Sept. 29.

such marginal extensions. Thus the impetus to increase pioneering research remains. To the extent that these research efforts are successful, commercialization of the new compounds will raise total bulk drug production worldwide.

Ironically, another effect of the law has been to force generic drug firms to begin pioneering research to develop new compounds. This is because generic houses can expect the backlash of the paucity of new compounds that came out of the discovery companies in the 1970s. The number of drugs coming off patent in the U.S. peaked at 19 in 1984 and will decline to five in 1996. These are the compounds from which new generic dosage forms can be selected. To sustain their growth, generics firms must take up the slack by discovering their own compounds.

The effort is under way. Mylan Laboratories of Pittsburgh, a well-known marketer of generic drugs,

Continued on page 50

proval for generic dosage forms of drugs whose patents have expired here. The other section lets discovery companies apply for extensions of the lives of their U.S. drug patents in proportion to the amount of time those drugs spent in FDA approval procedures.

One effect of the law may be to stimulate U.S. discovery companies to redouble their research efforts to develop new compounds, which can then get patent protection. Even before passage of the law easing generic approval, domestic discovery drug firms increased their research spending 17% per year to \$3.25 billion in 1984 from \$1.75 billion in 1980. These increases were in response to the double crunch of large numbers of compounds discovered in the 1960s coming off patent in the 1980s, combined with the relatively sparse discoveries of the 1970s.

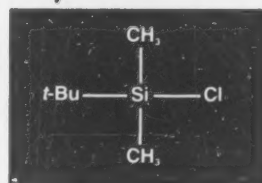
And U.S. pioneer drug firms can take little comfort in the part of the law that extends patent lives for many of their compounds. To date, extensions applied for are measured in hundreds of days rather than in years. The easier Abbreviated New Drug Application procedures set up by the law far outweigh benefits of

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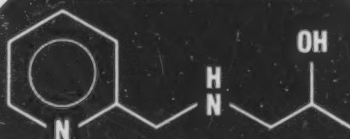
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Product Report

recently got FDA approval of a New Drug Application to market a drug for hypertension that contains 60% triamterene and 40% hydrochlorothiazide. The company says that this proportion is more effective and the dosage form more available for absorption than the competing brand-name 2:1 product of SmithKline Beckman. Mylan president Milan Puskar says the company also has new compounds in research.

Rugby Laboratories of Rockville Center, N.Y., which is perhaps the biggest U.S. marketer of generics, also has a number of new compounds in the pipeline, says chairman Michael Ashkin. And Udo Vetter of Martec says that his firm, recently founded to market generics, has begun pioneering research. This turn to pioneering research by generics firms will raise the level of such research here, increase the chances of finding new compounds, and lead to bulk production of any such finds.

Another effect of the law may be to heighten searches by pharmaceutical companies for new, patentable dosage forms for their older compounds. Among developments in this area, drug firms are steadily signing up to formulate their compounds around the controlled-release technology of Pennwalt Corp.'s Pharmaceutical Division. This technology binds drugs to cationic or anionic ion exchange resin beads, which are then encased in ethylcellulose membranes.

Again, the recently founded Elan of Ireland is a company whose business is to develop alternative, improved formulations for its clients. The company gains approval from Irish authorities to test new formulations of already approved compounds in healthy volunteers more quickly than American firms can from FDA. Insofar as its services to the American drug industry are concerned, Elan verifies performance of the optimum formulation for a particular compound's chemistry and therapeutic use, and turns the information over to its clients for them to take through FDA. A U.S. subsidiary, Elan Pharmaceutical Research of Gainesville, Ga., has the capacity to produce the dosage form if desired.

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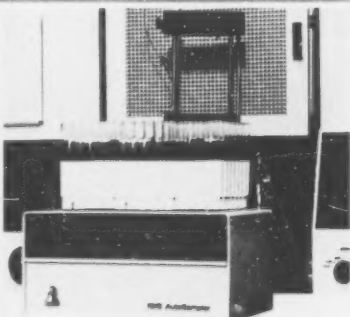
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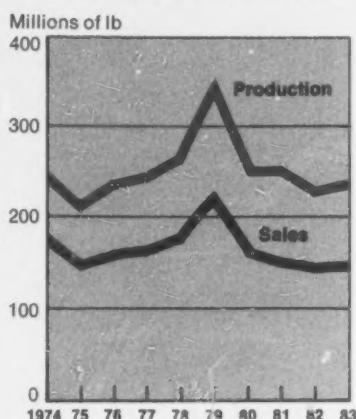
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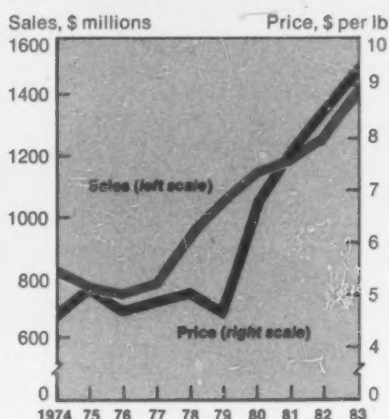
Product Report

U.S. medicinal chemicals volume has leveled off ...



Source: International Trade Commission

... but rising prices have caused value to increase



For doctors, the attraction of controlled drug release is once-a-day doses for chronic illnesses. Having to take their medicine only once daily may increase the likelihood that patients will keep up their medication in comparison with more complex schedules. To the extent that reformulation of older compounds is successful, the life cycle of older compounds will be longer, sustaining their worldwide production in bulk.

Though effects of the law seem to be to raise future levels of bulk drug production volumes, the effects on value are mixed. New, patent-protected compounds from pioneering research can command relatively higher prices in bulk, thus contributing to a rise in overall value. Conversion of older compounds to generics will lead to searches for lower-priced bulk compounds, which will tend to lower overall value.

Although there are many factors that could raise worldwide bulk drug production volume, there is a question of where it is to occur. Here again, one effect of the new law on easier generic drug approval is an opportunity to shift production back to the U.S. This is because there will be a momentary shortage of the worldwide, multipurpose, FDA-approved plant capacity needed, as domestic marketers of generics look about for supplies of the 56 compounds that will come off patent in the U.S., from 1984 (when

the law became effective) through 1987.

Propranolol is a case in point. Martec was left with only one choice among three world suppliers when production of the other two was spoken for. To develop a domestic source, the relative newcomer Martec would have to convince an American company that it was a responsible bearer of costs of equipment, process development, and creation of the Drug Master File. Prices for bulk propranolol would be at least twice those of Cosma's.

A future development that also could cause the U.S. generic drug industry to look to domestic sources is a proposed bill forbidding imports of products made by processes that are patented in the U.S. This bill is sponsored by Sen. Charles Mathias (R.-Md.) and Sen. Frank Lautenberg (D.-N.J.). Bulk drug makers continually perfect their chemical processes; thus, patents on processes could expire here later than those on compounds themselves.

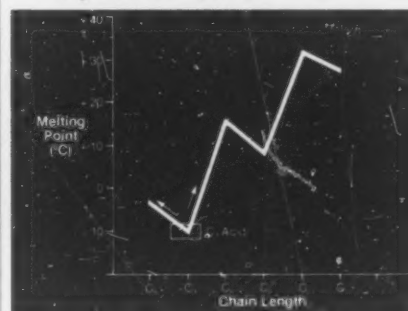
The proposed process patent law would make buyers of imported products liable for infringements of U.S. process patents by overseas suppliers. Unable to be sure in advance if a foreign bulk drug maker was using a process patented in the U.S., American generics firms might be wary of litigation and not import the drug.

The bill's strongest supporters are Allied Corp. and Corning Glass

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Medicinal chemicals: definitions

The medicinal chemicals covered in this report are those for human medicine alone. They are made by organic synthesis, isolation from plant and animal sources, and extraction from fermentation broths. They exclude amounts for veterinary, agricultural, or non-medical use. Not covered, for example, are vitamins, steroids, or antibiotics for animal feeds, or quinine for tonic water. Also excluded are substances not easily expressed in pounds of chemical entities such as vaccines and blood clotting factors.

Among human medicinal chemicals are antibiotics to treat bacterial infections. These include aminoglycosides such as gentamycin, cephalosporins such as cephalothin, the natural penicillin G and the semisynthetic ampicillin, and tetracyclines. Such sulfa drugs as sulfadiazine are used to prevent bacterial infections. Chloroquine is an antiparasitic against malaria.

Cardiovascular agents treat high blood pressure and heart disease. Among antihypertensives are Rauwolfia alkaloids like reserpine. Hydrochlorothiazide is a diuretic, which lowers blood pressure by increasing urine production. Such cardiac glycosides as

digoxin stimulate heart beat. Propranolol is a β -blocker used to treat both abnormal heart rhythms and hypertension.

Agents active in the central nervous system include the analgesic aspirin, the nonsteroid anti-inflammatory agent ibuprofen, the minor tranquilizer diazepam, the major (antipsychotic) tranquilizer thioridazine, the antidepressant imipramine, the sedative phenobarbital, the antiepileptic valproic acid, and L-dopa, used to treat Parkinson's disease.

Drugs classed as respiratory agents include the antihistamine chlorpheniramine for "stuffiness" and theophylline for asthma. Among steroids, corticosteroids are also used for asthma and to treat inflammatory diseases like arthritis. As steroid sex hormones, progestogens and estrogens go into birth control pills.

Medicinal chemicals also include vitamins. Methotrexate is an important anticancer drug. Oral tolbutamide maintains good blood sugar levels in many adult-onset diabetics, who thus avoid the need for insulin injections. Cimetidine has revolutionized treatment of ulcer patients.

Works. Allied is discontented with current laws to inhibit imports of its patented amorphous metal alloys. Corning has been fighting imports of fiber optics materials whose process of manufacture infringes its patents.

Leading the fight against the process patent bill for U.S. generic drug marketers is the Generic Pharmaceutical Industry Association. According to GPIA president Dee Fensterer, present remedies to sue over domestic patent infringement and to petition the International Trade Commission to exclude infringing imports are adequate. Moreover, the proposed bill would no longer require patent holders to use their U.S. patents in this country to gain protection. It would also enable a U.S. producer to shut out imports made by a certain process overseas by patenting that process for the first time here. And the bill could subject importers to legal costs

even if they won suits over process patent infringement.

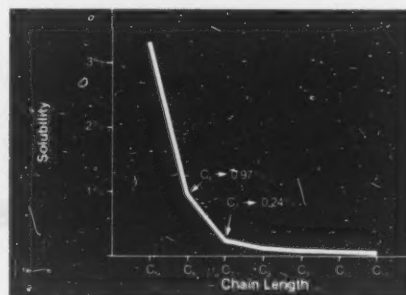
The U.S. bulk medicinal chemical production industry numbered 92 firms in 1983, according to the International Trade Commission, which has not published figures later than that year. This number is not much changed from the 99 companies ITC listed in 1973. Of the 540 chemical entities ITC counts as medicinal chemicals, 428 were made by only one producer, 82 had two producers, 24 had three producers, four had four producers, and only two compounds, phenylpropanolamine and feed-grade choline chloride, had as many as five producers.

But if the number of U.S. producers has declined slightly through the years, volume has fallen off more sharply. Production of bulk medicinal chemicals peaked at 313 million lb in 1979, according to ITC, and had leveled off 25% lower at 233 million lb by 1983. These figures

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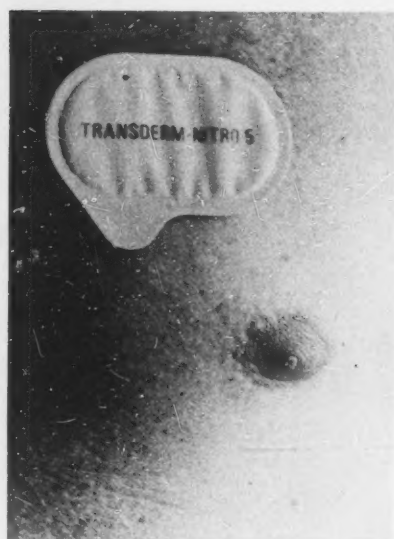
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CIRCLE 76 ON READER SERVICE CARD

September 16, 1985 C&EN 57

Product Report



Ciba's nitroglycerin patch is example of one of industry's new dosage forms

include production for applications other than strictly human medical use.

A shift toward domestic production could come from generic pharmaceutical companies themselves. Biocraft Laboratories is a well-known generic house that has long produced penicillin-type antibiotics at Waldwick, N.J., by fermentation and semisynthetic modification. Asked whether his company might integrate back into chemical production of bulk compounds, Puskas of Mylan says, "That's run through our minds." But Rugby's Ashkin is less optimistic about being able to get local approvals for location of a synthetic organic chemical plant in populous areas, and cites difficulties in getting a qualified workforce in less populous ones.

For the distant future, biotechnology could exert significant influences on bulk medicinal chemical production worldwide. As SRI's Hall puts it, biotechnology could lead to changes in the way that bulk drugs are made. Hall also points out, however, that research in this area could lead to therapies other than those now achieved by synthetic organic compounds.

As examples of things to come for old compounds by new methods, Hall notes that Eli Lilly already produces human insulin from cultures of *Escherichia coli* that have been genetically modified to make it. And

Bristol-Myers is developing genetically engineered streptomycetes to make the antibiotic amikacin directly as a replacement for current production of amikacin by chemical conversion of kanamycin. He also points to mammalian cell cultures as sources of interferon, antiviral vaccines, and urokinase, an enzyme used to dissolve blood clots in blood vessels of the lungs. And Hall says that plant cell cultures might become sources of compounds now obtained by harvesting and extraction of plants themselves. For example, Mitsui Chemical Industries makes alkannin, a naphthoquinone antibacterial and anti-inflammatory compound, from plant cell cultures.

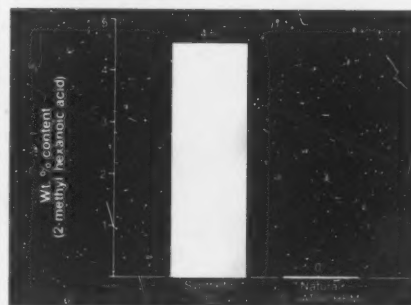
Another observer who has studied the potential of biotechnology in medicinal chemicals is Philip Rotheim of Business Communications Co., Stamford, Conn. Rotheim divides biotechnology into "old" and "new." Under old biotechnology, he puts fermentations with wild or mutated microorganisms; conversion of precursors to such products as steroids, vitamins, semisynthetic antibiotics, and 6-aminopenicillanic acid; and extraction of products from plant, animal, and human sources. For Rotheim, new biotechnology involves recombinant deoxyribonucleic acid, cell fusion, and plant and animal cell cultures. He links the two biotechnology types, saying that the recent blossoming of the new has led to a renewed interest in developing the possibilities of the old.

Rotheim estimates that bulk pharmaceutical products from old biotechnology will grow at 0.6% annually to \$7.46 billion in 1989 from \$7.28 billion in 1984. From a smaller base, he forecasts a 27.5%-per-year increase to \$186 million in 1989 from \$55.3 million in 1984 for bulk pharmaceutical products from the new. Most of this growth will be in insulin from recombinant DNA. Other products Rotheim expects from the new biotechnology by 1989 include human growth hormone, tissue plasminogen activator, and interferon. In the 1990s, he predicts appearance of blood anticlotting factors and hormone-releasing hormones, and therapeutic monoclonal antibodies. □

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CHEMICAL & ENGINEERING

NEWS

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■ **Special Presidential envoy on acid rain says modest control program is warranted.** Page 4

■ **MRI will study relation of combustion conditions in municipal waste incinerators to emissions of chlorinated dioxins.** Page 5

■ **Number of AIDS cases will continue to rise rapidly in next few years, Centers for Disease Control experts predict.** Page 5

■ **Eli Lilly & Co. will purchase Hybritech, developer of monoclonal antibody techniques.** Page 5

■ **Rohm & Haas' earnings hurt by lower sales of herbicides and hybrid wheat seeds.** Page 6

■ **California board of education rejects science textbooks because publishers have watered down treatment of evolution.** Page 6

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Business

Second-quarter earnings for biotechnology firms are mixed; growth for petrochemicals is forecast to head down. Page 15

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Spirited debate marked plenary session on nuclear weapon test ban at ACS meeting; queries answered on OSHA hazard communication rule; autopsy on "yellow rain" victim ambiguous. Page 19

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From the Chicago meeting: symposia on developing new materials for emerging technologies; salvaging waste plastics for reuse; bioadhesion mechanisms; cellulose structure; coal structure model; biomedical uses of polymers; organosilicon fungicides; and radioselective resins for waste disposal. Page 34

Bechtel subsidiary installs and operates custom-built, fluidized-bed incinerators at clients' waste sites. Page 44

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News Focus

Canada's petrochemical industry favors free trade with the U.S. but other segments of its chemical industry are hesitant. Page 7

Canada's Chemical Industry Split Over Canada-U.S. Free Trade Issue

Petrochemical sector favors free trade, whereas most small specialty chemical companies oppose it; producers of inorganic chemicals are in the middle

Earl V. Anderson, C&EN New York

When Canada's Prime Minister Brian Mulroney and President Ronald Reagan met in Quebec City on March 17 for what's been called the Shamrock Summit or Irish Love-In, bilateral free trade between the two countries was a top-priority item. It was clear then, and still is, that any free trade initiative would have to originate in Canada.

The top trade officials of each country were given six months to prepare a report on the possibilities. In Ottawa, Canadian Trade Minister James F. Kelleher is about set to deliver his report to Mulroney. It is almost certain to recommend an attempt to negotiate a bilateral free trade pact with the U.S.

Whatever policy evolves, it is sure to have a bearing on the chemical industries of both countries and the chemical trade between them. This article looks at the options available for bilateral free trade and their implications from a Canadian perspective. In a later article, C&EN will consider the U.S. point of view.

Anytime now, if it hasn't already happened since C&EN went to press, Canadian Trade Minister Kelleher will present a report to Prime Minister Mulroney. That report will outline possible ways to achieve freer trade (the buzzword in Ottawa is "enhanced" trade) with the U.S. It no doubt will recommend a preferred course of action.

In Canada, chemical industry leaders will be keeping a close eye on developments in Ottawa. So, too, will the trade experts in the U.S. chemical industry, because what's decided in Ottawa on free

bilateral trade between Canada and the U.S. will heavily influence the fortunes of those two industries.

Whether Mulroney chooses to steer his country toward more open trade with the U.S. remains to be seen. Before he was swept into office and for most of his first year at the helm, he stood solidly behind the idea of free, freer, or "enhanced" trade with the U.S. as the best possible way to guarantee growth in Canada's all-important export markets. Canadian political analysts have sensed that he mellowed somewhat recently—a reaction, no doubt, to an outburst of opposition in Canada to free trade with the U.S. Historically, many Canadians have never relished the idea of jumping into economic bed with their big, overpowering neighbor.

But Ottawa watchers still think that Mulroney will



Prime Minister Mulroney greets President Reagan at Shamrock Summit

Inorganics and fertilizer are Canada's strong chemical trade suit

Commodity	Exports to U.S.			Imports from U.S.			Trade balance	
	Total	% U.S.	Total	Total	% U.S.	Total	With U.S.	
Mixed fertilizers	\$ 18.6	63.3%	\$ 21.2	\$ 20.6	97.1%	\$ -2.6	\$ -5.1	
Plastics and synthetic resins	490.9	302.1	62.8	913.4	704.4	-332.5	-402.3	
Pharmaceuticals and medicines	113.8	33.6	29.5	411.8	191.8	-298.0	-158.2	
Paint and varnish	14.1	11.9	84.3	114.1	106.4	-100.0	-94.5	
Soap and cleaning compounds	21.0	14.2	47.6	29.8	23.9	-8.8	-9.7	
Toilet preparations	23.4	19.6	83.7	88.6	54.1	-65.2	-34.5	
Industrial chemicals	2267.4	1553.3	68.5	1657.6	1126.7	68.0	426.8	
Pigments and dry colors	41.9	37.2	89.0	132.0	70.3	-90.1	-33.1	
Inorganic chemicals	970.4	758.9	78.2	373.0	298.5	76.9	480.4	
Fertilizer chemicals	265.5	209.6	78.9	135.9	107.7	79.3	101.9	
Organic chemicals	989.8	547.6	55.3	996.7	650.2	-65.2	-102.6	
Other chemicals	201.0	119.7	59.6	1029.5 ^a	910.3 ^a	-828.5	-790.0	
Oils, fats, and waxes	15.6	9.2	58.9	96.2	85.1	-80.6	-75.9	
Agricultural chemicals, formulated	17.4	11.9	68.4	195.0	160.7	-177.6	-148.8	
Adhesives	5.4	3.7	68.5	30.9	27.5	-25.5	-23.8	
Industrial chemical specialties	157.8	94.4	59.8	653.4	591.1	-495.6	-496.7	
Explosives and ammunition	4.8	0.5	10.4	32.5	26.7	-27.7	-26.2	
TOTAL CHEMICAL & ALLIED PRODUCTS	\$3140.1	\$2080.7	65.2%	\$4186.0 ^a	\$3139.0 ^a	\$-1025.9	\$-1066.3	

^a Totals include imports of links not included in table. About \$22 million total, \$19 million from U.S. Note: Numbers may not add exactly because of rounding and conversion from Canadian to U.S. dollars. Source: Department of Regional Industrial Expansion (Canada)

opt for some sort of broad, comprehensive trade agreement with the U.S. He could make such a decision right after receiving Kelleher's report. Or he could delay his choice until he has an opportunity to review his options once again with his provincial premiers, probably in November.

In any event, "Things are hotting up in Ottawa on trade," says one government official. "Every day the decision is delayed costs us money."

If there is going to be a free trade arrangement between the U.S. and Canada, matters indeed will have to "hot up" in Canada. Those who follow the Canada-U.S. trade issue have overworked the cliché, but the ball actually is in Canada's court.

While Trade Minister Kelleher readies his report for the Prime Minister, a counterpart report, now in draft form, is being written in Washington for President Reagan. At press time, the U.S. report was on the desk of Clayton Yeutter, the new U.S. Trade Representative (USTR). The report is "nothing fancy," says deputy assistant USTR William Merkin. "It is mainly their initiative," says Merkin. "Canada is the key player." Merkin confirms what everyone connected with U.S.-Canadian trade already takes for granted. If Canada proposes something, the U.S. will respond to it. If the Canadians don't propose anything, U.S. trade officials certainly won't either.

It's not difficult to appreciate Canada's concern about its markets in the U.S., especially with the heavy protectionist clouds that now hang over Capitol Hill. Canadian exports last year hit \$83.8 billion (\$1.00 = 1.31 Canadian dollars). Of that, \$63.3 billion went to the U.S. That's a staggering 76% of the total. Canada's next largest export market took only 6% of the total—and that was the 10-country European Economic Community. Only 5% of Canada's exports went to third-place Japan.

Canada is the largest single-country export market

for the U.S., too. Last year, 21%—\$46.5 billion—of U.S. exports moved into Canada. That's a lot, but a far cry from Canada's 75% coming the other way.

In chemicals, the story is pretty much the same. Each country is the other's best single customer. But Canadian chemical companies are much more dependent on U.S. markets than U.S. companies are on Canadian outlets. That shouldn't be surprising. Canada's population, at 25 million, is roughly a tenth the size of the 237 million in the U.S.

Some other comparisons give a fuller picture. In 1984, Canada exported \$3.1 billion in chemicals—66% of it to the U.S. Of the \$22.3 billion in U.S. chemical exports last year, only 12% were shipped to Canada. Canada's chemical industry ran an overall trade deficit last year; it also was in the red in its trade with the U.S.

More than most countries, Canada is a trading nation. Close to 30% of its national income depends on international trade. Over the past few years, exports have accounted for 24 to 28% of chemical industry shipments. With the publicity that the trade issue has received in Canada lately, virtually every Canadian knows that his or her country is the only major industrialized nation without a captive market of 100 million or more people.

That's why the U.S. looms so large as Canada considers its trade policy for the future. Multilateralism notwithstanding, numbers such as those have convinced many Canadian business, academic, and political leaders that a bilateral trade pact with the U.S. is vital to Canada's future.

Not all of them to be sure. Many influential Canadians still think that Canada would be giving away the store if it entered a free trade pact with the U.S. Certainly, as the smaller partner in a Canadian-U.S. free trade arrangement, Canada would have the more difficult adjustment. In addition to the traditional

"branch plant" concerns—Canadian plants owned by U.S. companies shutting down and costing Canadians jobs—there are other deep-seated fears. One way or another, they revolve around the concern that Canadian political and cultural independence will be jeopardized under a free trade arrangement with the U.S.

Nevertheless, many authoritative studies have come out recently in favor of attempting to strike a bilateral trade deal with the U.S. The message in most of them is that the time to move is now. International competitive pressures are increasing. So is protectionism, especially in the U.S. And, given the enormous U.S. trade deficit, Canada's all-important markets in the U.S. may become blocked by additional legislation, even if that legislation isn't necessarily aimed at Canadian goods. Many leading Canadian trade experts see a very narrow "window of opportunity" to negotiate a bilateral free trade pact with the U.S.—a window that could close when off-year Congressional campaigning starts next year.

Typical of many of these studies is "Taking the Initiative—Canada's Trade Options in a Turbulent World." This study, prepared by the prestigious C. D. Howe Institute, Toronto, Ont., concludes that a bilateral trade agreement with the U.S. offers the best prospect of securing the export access that the Canadian economy needs.

In common with many Canadian leaders, Howe doesn't want Canada to abandon efforts to improve its trade position through multilateral trade negotiations under the General Agreement on Tariffs & Trade. It does believe, however, that the protectionist bias in EEC and tensions between the U.S. and Japan make significant progress "seem unlikely for several years, and perhaps longer."

It concludes, then, that bilateral free trade with the U.S. (along with multilateral negotiations) is the only choice that offers a realistic prospect for significantly improving Canadian export opportunities. What it suggests is a Canadian-American free trade area (CAFTA).

By process of elimination, says C. D. Howe, a CAFTA approach is the only effective way of initiating bilateral trade negotiations with the U.S. It rejects outright the sectoral approach, under which specific industries or "sectors" are earmarked for liberalized trade. A stab at sectoral agreements between the U.S. and Canada was tried as recently as 1983. Petrochemicals were one of the sectors under serious consideration.

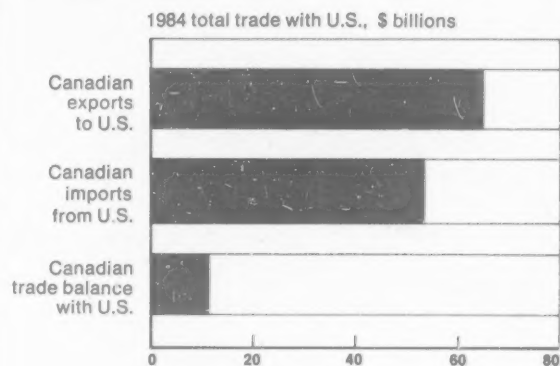
C. D. Howe says that it's too hard to identify individual sectors in which both countries would have mutual interests (and find mutual benefits) in freer trade. Much negotiating effort, says the institute, could be spent obtaining very disappointing results. That's no doubt why the attempt at sectoral free trade has fallen by the wayside. It's also why almost everyone agrees that no attempt will be made to revive it.

With minor variations on the theme, many other major organizations agree with C. D. Howe that a comprehensive trade agreement with the U.S. is the way to go. Among them are the Canadian Export Association, the Canadian Manufacturing Association, and the Canadian Chamber of Commerce.

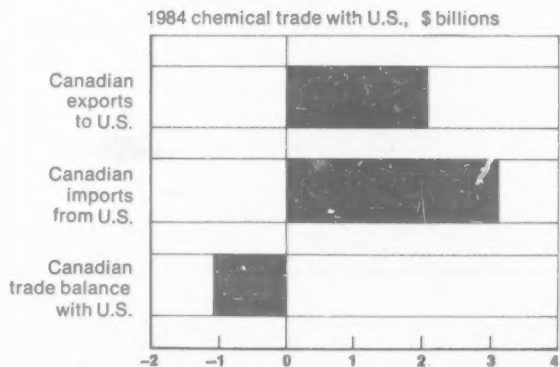
Recently, a Canadian commission recommended that the Canadian government move quickly toward a free trade arrangement with the U.S. The commission, officially the Royal Commission on the Economic Union & Development Prospects for Canada, was appointed three years ago to study the Canadian economy and its prospects. Known more popularly as the Macdonald Commission after its chairman, former Finance Minister Donald Macdonald, it suggested that all tariffs between the two countries be phased out over 10 years and that a U.S.-Canadian intergovernmental agency be created to supervise trade rules. Even a special joint committee of Canada's Senate and House of Commons, with representatives of all the country's major political parties, has urged a stab at more liberal trade with the U.S. Of the 10 Canadian provinces, nine are in favor of freer trade with the U.S. Ontario, with its huge manufacturing base built up largely behind high tariff walls, is the lone provincial holdout. To nobody's surprise, most of Canadian labor is also against freer trade.

Beefing up Canadian exports was a key Mulroney campaign pledge. And he cannot realistically ignore the groundswell of support that has emerged throughout Canada for at least an attempt to negotiate a free

Canada runs a trade surplus with the U.S. . . .



. . . but not in chemicals



Sources: Statistics Canada, Department of Regional Industrial Expansion (Canada)



Kissick: there will be some pluses and some minuses, but on balance we should benefit

trade agreement with the U.S. That's why Ottawa watchers are betting that Mulroney will opt for as broad and as comprehensive a trade arrangement as possible with the U.S.

How does Canada's chemical industry feel about that? It all depends, as always, on whom you talk to.

Some firms are passionately in favor of free trade with the U.S.; some are lukewarm; others are strongly opposed. The pro free-traders tend to be bunched in the petrochemical sector of the industry. Most small specialty chemical firms want no part of it. In the middle are the producers of inorganics, on which most tariffs already have been eliminated or soon will be.

Donald E. Wood, for instance, says that Polysar is in favor of free trade with the U.S. Wood, in charge of business logistics and development for Polysar's basic petrochemicals group, notes that the company would like to see free trade in styrene, polystyrene, and polyethylene. Polysar doesn't make polyethylene, but supplies ethylene to those that do, now that it has acquired all of Petrosar.

Polysar is based in Sarnia, Ont. Further west, in Alberta, is where most of Canada's petrochemical capacity is built. It's also where most of the chemical industry's free-trade support is concentrated. A. E. (Sam) Egglestone, senior vice president of Alberta Gas Chemicals Ltd. (AGCL), says that tariffs on methanol should be dropped by both countries. AGCL has 240 million gal per year of methanol capacity at Medicine Hat, Alta.

Novacor Chemicals Ltd. also favors free trade with the U.S. The company is a major petrochemical producer in Canada. It has 2.7 million lb per year of ethylene capacity, about 60% of Canada's total. It has about 25% (600 million lb annually) of Canada's polyethylene capacity and about the same percentage of polyvinyl chloride capacity (200 million lb).

Naturally, Novacor also would have liked to see sectoral free trade in petrochemicals. It still does. But Novacor's position on free trade with the U.S. goes beyond that. Says John P. Sutherland, the company's vice chairman, "We most urgently seek freer trade ... in a comprehensive agreement with the U.S."

Along with the rest of the petrochemical sector, Union Carbide Canada Ltd. feels strongly about a petrochemical accommodation with the U.S. But as company chairman and chief executive officer W. Norman Kissick points out, Carbide Canada is in many businesses besides petrochemicals; therefore the impact on the company of a comprehensive free trade arrangement is not that clear-cut. "There will be some pluses and some minuses," says Kissick, "but on balance, we should benefit."

Kissick cautions, however, that about 75% of the company's business is selling to other Canadian companies. "If they're in jeopardy [as a result of free trade], we won't survive," he says. "We listen to them."

Unarguably the most diversified of the large Canadian chemical companies is C-I-L Inc. Its vice chairman, David I. W. Braide, says, "C-I-L has nailed its flag firmly to the mast of as broad an agreement as possible." As a diversified company, Braide warns, C-I-L could be hurt by removing some Canadian tariffs. But in the long run, he adds, C-I-L will benefit more through free trade than with the status quo. "It will be an invigorating process for the entire Canadian economy," says Braide.

These are all large companies. Among smaller chemical companies, affection for free trade with the U.S. doesn't run that high. An executive of one small Canadian chemical specialty company points out that companies like his were developed behind a tariff wall. "There will be no more Canadian plants built in secondary or tertiary industries if we go free trade," he says.

Indeed, the Canadian Manufacturers of Chemical Specialties Association hasn't even taken a position on the free trade issue. Its president, Peter Nott, doubts it ever will. Its 100-odd company members are just too diverse to come up with a policy that will satisfy them all, he says.

Opinions such as these—pro, con, and all shades in between—have been pouring into the Department of External Affairs ever since Trade Minister Kelleher issued a discussion paper, "How To Secure and Enhance Canadian Access to Export Markets" earlier this year. The paper asked for information, views, and perceptions on the trade issue. The department got them in droves. After laying out some background data, the discussion paper really boils down to four questions on Canada-U.S. trade relations:

Should we continue as we have in the past?

Could we negotiate sectoral or functional arrangements?

Do we need a comprehensive arrangement? Is a framework agreement necessary?

The discussion paper virtually answers its own questions on the first two. On the status quo, it notes that the "present situation" may not adequately serve Ca-

nadian economic interests. And it wonders if enough political and private sector support can be mustered for a sectoral or functional approach. Probably not. It's been tried and has gotten nowhere, though it still remains a petrochemical industry favorite in Canada.

The big disadvantage of the sectoral approach is that it is difficult to get a balance of benefits on both sides of the border in a narrow industrial sector. That is why the U.S. chemical industry wanted to broaden the petrochemical approach taken by the Canadians as recently as last year. Another argument against sector agreements is that they may run counter to GATT rules. There is, of course, the long-standing Canada-U.S. auto pact, which provides duty-free trade for automobiles and most original parts, subject to certain Canadian production guarantees. But trade officials doubt that a new sectoral agreement between the U.S. and Canada would get GATT's blessing again.

That leaves a comprehensive agreement and a "framework" agreement. Support in Canada for a comprehensive agreement has been growing. Such an approach would remove tariff and nontariff barriers on substantially all bilateral trade. It would conform with GATT requirements. And it would leave intact the trade barriers that each country maintains against third countries.

After penetrating the bureaucratic language barrier, a "framework" agreement would be nothing more than a jawboning exercise. Under a "trade enhancement agreement," another name for the same thing, the two countries would form a joint consultative committee to discuss issues and develop work programs. Specific mechanisms could be set up to discuss and possibly resolve trade conflicts.

The major chemical industry response to the discussion paper has come through the Canadian Chemical Producers Association (CCPA), Canada's counterpart to the Chemical Manufacturers Association in the U.S. CCPA represents 66 companies that produce about 75% of Canada's industrial chemical and synthetic resin output. CCPA divides itself into three product sectors—petrochemicals, inorganics, and organic/specialty chemicals.

Therein lies its problem. Member companies have different attitudes on free trade with the U.S., depending upon their product line. Member companies come in all sizes; some are national, others multinational. What makes sense for one doesn't necessarily make sense for the other. Because its membership is anything but homogeneous, it's very difficult for CCPA to take a solid, one-posture position.

So it doesn't. Understandably, it tries to pick the best of all the worlds that Kelieher's discussion paper has to offer. "There are no black and white choices," CCPA has told the Department of External Affairs.

CCPA rejects the status quo option outright. As protectionist pressures increase, especially in the U.S., CCPA believes that continuing to do what Canada has done in the past will be like jumping continually from one brushfire to another.

CCPA likes sectoral free trade for petrochemicals, even though it knows that the narrow sectoral ap-

Canada's petrochemical wish list

When sectoral free trade between the U.S. and Canada was still a possibility, the Canadian chemical industry strongly pushed petrochemicals as one of the sectors. Here are its candidates for petrochemical free trade:

Product	Tariff rates ^a (% and/or cents per lb)	
	Canada	U.S.
Styrene	7.5%	7.4% ^e
Cyclohexane	10.0% ^b	0.9¢ + 12.5%
Ethylbenzene	9.2% ^b	0.5¢ + 17.3%
Carbon tetrachloride	9.2%	2.3%
Ethylene dichloride	10.0%	0.6¢ + 3%
Vinyl chloride	12.5% ^b	12.0%
Propanol ^c	12.5%	14.0%
Methanol	10.0%	18.0% ^d
Ethylene oxide	9.2%	9.0%
Ethylene glycol	10.0%	12.0%
Phenol	9.2%	1.3¢ + 12.5%
Acetic anhydride	12.5%	3.5%
Acetic acid	12.5%	1.8%
Adipic acid	12.5%	0.1¢ + 19.8%
Hexamethylenediamine	12.5% ^b	20.0% ^e
Acrylonitrile	6.3% ^b	11.6%
Alkylbenzene	Free	0.5¢ + 17.3%
Polyethylene	10.1–11.1%	12.5%
Polyvinyl chloride	9.5%	10.1%
Polystyrene	9.5%	0.4¢ + 9.2%
Vinyl acetate	12.5%	3.8%
Styrene-butadiene latex ^f	Free	Free
Syrene-butadiene latex ^g	9.5%	0.4¢ + 9.2%
Acetaldehyde	12.5% ^b	8.0%
Adiponitrile	10.0%	13.5%
Nylon 6	7.5–10.0%	6.3%
Nylon 66	8.5–10.0%	6.3%

^a Tariff rates effective January 1987 when Tokyo round tariff cuts are fully phased in.
^b Free under a temporary rate reduction for plastics use. ^c 1-propanol and 2-propanol. ^d Free for fuel use. ^e Benzene based. ^f Rubber. ^g Nonrubber. Sources: Canadian Chemical Producers Association.

proach has been all but abandoned. "We think that a purely sectoral approach would not get off the ground," says Jean Belanger, CCPA's president. But CCPA's petrochemical members want it. CCPA wants it for them. Yet, other member companies are less than enthusiastic about sectoral or any other kind of free trade.

CCPA deftly runs the gauntlet by advocating what Belanger calls a "pragmatic" approach. It supports speedup efforts to establish a framework, consultative agreement, such as a trade enhancement agreement. That, after all, involves only talk, and little harm can come from it.

But CCPA hedges on a broad, comprehensive agreement. It wants an effort to be made, but it should be, says CCPA, "a continuing effort to assess and build consensus." In other words, more study, more talk.

All of this study and talk, of course, will take time. But CCPA points out that some opportunities for freer trade shouldn't wait until all of the study and talk end. One of those opportunities, of course, is petro-

chemicals. What CCPA proposes, then, is integrating sectoral free trade negotiations for petrochemicals into what it calls a "broad negotiating framework." But that broad negotiating framework, as CCPA sees it, is little more than further study and more talk. The message that CCPA hammers home to the Department of External Affairs is that "the Canadian petrochemical industry needs action now." Whatever else is done, CCPA wants to see a joint working party established to negotiate a free trade pact in petrochemicals.

Petrochemical free trade has been a goal of Canada's chemical industry for some time. After the Tokyo round of trade negotiations ended in 1979 with U.S. tariff concessions somewhat less than what Canada sought, Peter Lougheed, at the time Alberta's Premier, suggested a free-trade approach on about 10 major petrochemicals. It was the time of energy crisis. Canada's pitch was: If you want our energy, you must take some of our petrochemicals with it.

Last year, a petrochemical task force issued a major report on problems and prospects of the industry. The major issue was Canadian energy and feedstock poli-

cy. But the number two problem was trade, said the report.

Even before the task force issued its report, CCPA was busy on sectoral free trade for petrochemicals. In 1983, it broached the subject in a couple of meetings with its counterpart CMA in the U.S. It compiled a list of petrochemicals that it considered possible candidates for free trade.

On the U.S. side, CMA made it clear that a "government umbrella" would be needed if petrochemical free trade talks were to continue. Former Prime Minister Trudeau first opened that umbrella when he proposed that the two countries consider four primary industries as candidates for sectoral free trade. Petrochemicals were one of the secondary candidates. When the Conservatives ousted the Liberals in Canada last year, the umbrella closed, if only temporarily. And by the time Reagan and Mulroney met in Quebec City, sectoral free trade had been discarded as a negotiating option.

Certainly, however, Canada's preoccupation with free trade for petrochemicals is understandable. During the 1950s and 1960s, Canada's petrochemical industry had small plants geared to the domestic market. Meanwhile, economical, world-scale plants were being built elsewhere. Even with inexpensive and abundant feedstock, Canadian producers couldn't compete. Between 1965 and 1974, petrochemical production in Canada rose only half as fast as domestic consumption. Trade moved from balance to a \$460 million deficit.

In the early 1970s, Canada's petrochemical producers went on a construction binge, building world-scale plants of their own, particularly in gas-rich Alberta. These plants still had only a small domestic market, so exports became critical. Producers were able to increase petrochemical exports six-fold between 1974 and 1983. Canada has had a petrochemical trade surplus every year since 1979.

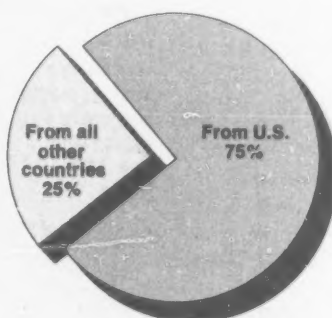
About 45% of Canada's basic petrochemical production is exported. More than half of those exports, 57%, go to the U.S. No wonder the petrochemical sector of Canada's chemical industry has its fingers crossed for free trade with the U.S. Meanwhile, its eyes are on Washington, D.C., where it fears that a protectionist rash will rub off on Canadian petrochemicals.

CCPA's inorganic and organic/specialty chemicals members are in a different boat, however. CCPA is working now with its inorgan-

Canada's chemical trade with U.S. is more important...



1984 chemical exports = \$3.14 billion

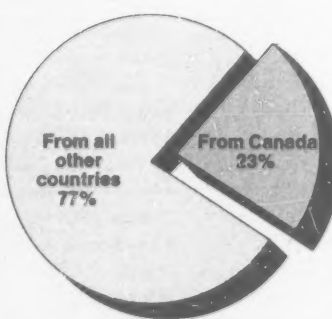


1984 chemical imports = \$4.17 billion

... than U.S.'s chemical trade with Canada



1984 chemical exports = \$22.34 billion



1984 chemical imports = \$13.70 billion

Sources: Department of Regional Industrial Expansion (Canada), U.S. Bureau of the Census

ics members to clear up some uncertainties about their ability to compete internationally and to define more clearly their most worrisome nontariff barriers.

In the organics/specialties segment, the situation is more clear-cut. Many companies just don't want free trade with the U.S. or anybody else. "The viability of firms [in this sector] would be seriously impaired, if not destroyed," says CCPA, if a free trade agreement forced Canada to remove tariffs on their products.

In the inorganic chemicals industry, about 75% of total shipments are commodity products, made in large, efficient, world-scale plants using the best technology available. These plants are big enough to serve both domestic and foreign markets. For some commodity products, free trade with the U.S. already exists, or is very close. Tariffs on sulfuric acid, chlorine, and caustic soda will disappear in 1987.

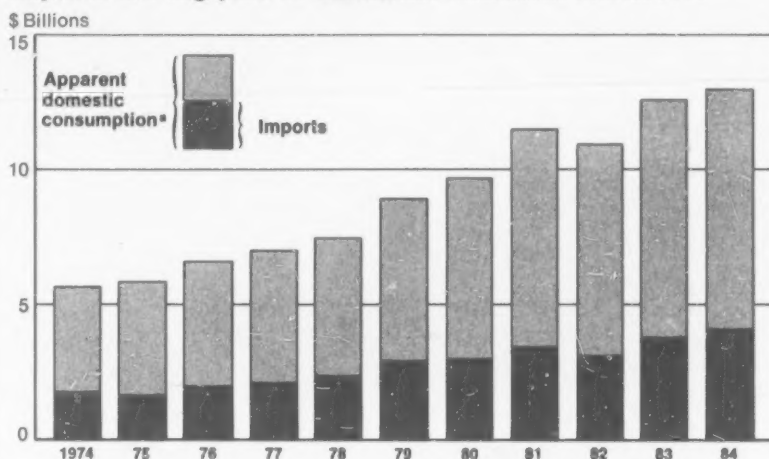
The remaining 25% of Canada's inorganics shipments are many small-volume products produced in small plants built to serve regional, even local isolated markets. They could be vulnerable if they lost tariff protection. Historically, Canadian inorganics producers have had a serious cost disadvantage competing against U.S. companies.

Thus the prospect of free trade with the U.S. gets a mixed reception among Canada's inorganics producers. In some commodity products, tariffs have all been eliminated already. But CCPA feels that others would be hard hit if Canadian tariffs were erased. Meanwhile, as tariffs disappeared, nontariff barriers would become more important. CCPA wants more time to take a closer look at them.

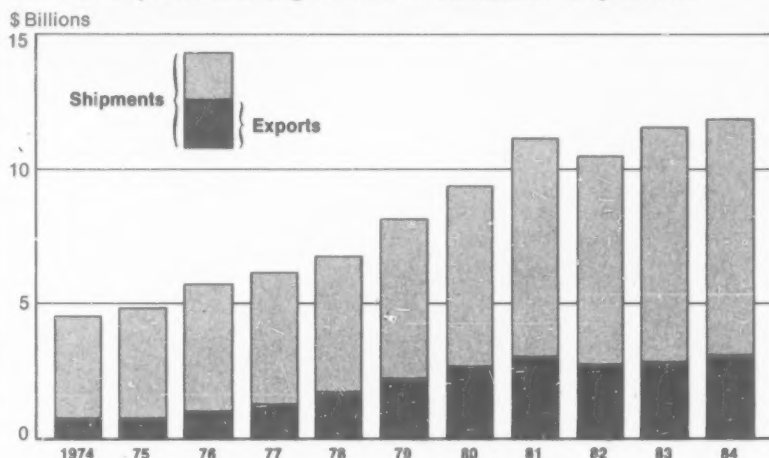
Canadian companies in the organics/specialties sector say they would feel naked stripped of their tariff protection. They have no raw material price advantage over U.S. producers, says CCPA. Many products in the sector serve small, specialized markets. They are impractical to produce in Canada. Already, about two thirds of domestic demand is satisfied by imports. Canadian specialties production doesn't usually start until the domestic market is large enough to support it. Even then the plants usually are small, flexible, multipurpose units with batch, rather than continuous, operation.

Their small size puts them at a disadvantage, says CCPA. Canadian specialties producers usually get their

Imports are big part of Canadian chemical market ...



... and exports are big factor in chemical shipments



^a Apparent domestic consumption is defined as domestic shipments plus imports minus exports.
Source: Department of Regional Industrial Expansion (Canada)

technology through licensing. CCPA fears that these arrangements could dry up under free trade, and the companies' small size makes it uneconomical for them to develop their own technology.

For CCPA, then, developing a response to the trade minister's questions on free trade has been a case of different strokes for different folks. The Society of the Plastics Industry of Canada (SPIC) has no such problems.

Canadian plastics processors already have almost duty-free access to the U.S. market, and its own domestic market remains fairly well protected. As far as bilateral free trade is concerned, then, SPIC would just as soon leave things the way they are.

No doubt, each segment of the Canadian chemical industry will refine its position as the push toward bilateral free trade progresses. But the first step must yet be taken by the prime minister in Ottawa. The ball still is in his court. Then it will be a question of whether the U.S. can, or wants to, play ball. □

Biotechnology Firms Post Varied Results in Second Quarter

Producers of diagnostics based on monoclonal antibody technology register strong gains; earnings deficit increases at Genex

David Webber, C&EN New York

The variety of financial results reported by biotechnology-based companies for the second quarter of 1985 continues to reflect the range of progress the firms have achieved in following their business plans. A few companies are turning in respectable profits on product sales, whereas others report minor to substantial net income still derived almost exclusively from contract research fees. Most firms, however, continue to lose substantial amounts of money each quarter as they plow

revenues back into their efforts to find a safe spot in the ever more precarious biotechnology field.

Among the handful of companies with significant revenues from their own biotechnology-based products, Hybritech—which agreed last week to be acquired by Eli Lilly for more than \$300 million—continues to set a strong financial pace. The San Diego company, which manufactures and markets diagnostic kits using monoclonal antibody technology, more than doubled its revenues in second-quarter 1985 to \$14.7 million, compared with last year's second quarter. On the basis of product sales alone, the improvement was even better; sales jumped to \$8.1 million, up 134% over the same period a year earlier and up 25% over first-quarter 1985.

Almost all the company's remaining revenue reported in the second quarter came from contract work,

revenues for which rose 77% in the quarter. Most of those fees, Hybritech notes, paid for product development programs principally aimed at moving the company into both new diagnostic markets and therapeutics. The only revenue source to decline was interest income, which fell as cash was invested in working capital and facilities. At the end of June the company had \$12.3 million in cash and cash equivalents. As a result, Hybritech's net income soared more than 1000% over the same period a year earlier to \$538,000 (exclusive of an extraordinary tax credit).

Hybritech's rapid move to profitable commercialization of its products has been largely the result of its concentration on monoclonal antibody-based diagnostics. For the most part, markets already exist for such products, regulatory approval hurdles are much lower than for

Most biotechnology firms still operate in the red

	SECOND-QUARTER 1985 ^a							FIRST-HALF 1985 ^a						
	Revenues ^b	Earnings ^c	Change from 1984		Profit margin ^d			Revenues ^b	Earnings ^c	Change from 1984		Profit margin ^d		
	(\$ million)		Revenues	Earnings	1985	1984		(\$ millions)		Revenues	Earnings	1985	1984	
Amgen	\$ 3.337	\$-2.035	77%	def	def	def	\$ 6.687	\$-3.753	83%	def	def	def		
Bio-Response	1.118	-0.613	336	def	def	def	1.677	-1.620	276	def	def	def		
BioTechnica International	1.270	-0.676	229	def	def	def	2.495	-1.434	216	def	def	def		
Biogen	6.686	-2.784	-14	def	def	def	11.550	-7.760	-16	def	def	def		
California Biotechnology	2.362	0.048	15	23%	2.0%	1.9%	4.349	-0.061	7	def	def	3.1%		
Centocor	5.430	0.413	97	601	7.7	2.2	9.820	0.667	87	966%	6.8%	1.2		
Cetus	10.770	0.534	-21	45	5.0	2.7	23.398	0.745	-9	57	3.2	1.9		
Collaborative Research	2.127	-1.193	-43	def	def	def	4.342	-2.253	-25	def	def	def		
Damon Biotech	0.924	-2.614	-40	def	def	def	1.599	-5.609	-45	def	def	def		
DNA Plant Technology	1.068	-0.121	30	def	def	def	2.014	-0.250	39	def	def	def		
Genentech	21.412	1.101	24	76	5.1	3.6	41.576	1.816	28	80	4.4	3.1		
Genex	4.800	-2.300	-41	def	def	def	9.400	-4.700	-33	def	def	def		
Hybritech	14.676	0.538	104	1070	3.7	0.6	26.260	0.673	110	683	2.6	0.7		
Molecular Genetics	1.902	-0.735	-14	def	def	0.9	4.242	-1.214	-12	def	def	def		
Monoclonal Antibodies	1.792	-0.601	72	def	def	def	3.317	-0.994	96	def	def	def		

a For three-month or six-month period ending closest to June 30. b Includes sales, contract research, royalty, and interest revenues. c Excludes extraordinary credits. d After-tax income as a percentage of revenues. def = deficit

human therapeutics, and the technology is far easier than that for, say, recombinant DNA. As Hybritech and other companies that are currently selling diagnostic kits attempt to make the leap into monoclonal-based therapeutics, which are potentially far more lucrative, they will have to overcome much greater obstacles to commercialization of their properties.

Reporting good sales increases from similar products, though on a smaller scale, is Monoclonal Antibodies Inc. The Mountain View, Calif., firm raised its total revenues 72% in the second quarter from the year-earlier period to nearly \$1.8 million. For the first half of 1985, the company recorded revenues of \$3.3 million, up 96% over the equivalent period last year. Of the second-quarter revenues, almost \$1.4 million came from product sales, a gain of 89% on an annual basis. Still, the company continues to report losses—\$601,000 in the second quarter, for example. Finances were improved, however, through private stock placements in May and July that netted the company a total of \$1.4 million.

The really positive news for Monoclonal Antibodies in recent months, however, was the late August ruling by a judge of the federal district court in San Francisco, invalidating a Hybritech patent on a certain monoclonal antibody technology related to diagnostics (C&EN, Sept. 9, page 6). Hybritech had sued the smaller firm in March 1984, claiming patent infringement. The victory for Monoclonal Antibodies, which Hybritech may appeal, means the likely end to a severe drain on the company's finances. Direct legal costs in the second quarter alone totaled \$372,000. The company also hopes that, with the possibility of constraints on the company's products apparently gone, its standing with investors and customers will improve.

The biggest biotechnology-based company remains Genentech, which boosted second-quarter revenues 24% from a year earlier to \$21.4 million and net income 76% to \$1.1 million. Over the first six months of 1985, the company's revenues, 91% of which are derived from con-

tract fees, rose 28% to \$41.6 million, and earnings jumped 80% to \$1.8 million. Genentech, which continues to increase its R&D spending aggressively, is still marketing no proprietary products.

During the second quarter, Genentech broadened its collaboration with Boehringer Ingelheim, which bought just under 5% of the South San Francisco, Calif., company's common stock for \$40 million in a first-quarter private placement. The two firms announced a plan to establish a cancer research center in Vienna, and a joint venture called Genentech Canada was formed between Genentech and Boehringer Ingelheim (Canada) to market human pharmaceuticals developed by Genentech. In July, Genentech licensed some of its animal health care products to Ciba-Geigy for worldwide manufacture and marketing. The deal will bring Genentech \$42 million in cash plus royalties on product sales.

"This agreement will enable us to get our animal health products more quickly to market without diverting our focus from human health care," says Robert A. Swanson, Genentech's chief executive officer.

Among other firms with solid second-quarter increases in revenues, Amgen reported a 77% jump to \$3.3 million, while turning in a loss of \$2.0 million, slightly less than in the same period a year before. Amgen's expenses rose 36% from the year-earlier period to nearly \$5.4 million in the second quarter. The increase was caused primarily by added investments in process scale-up and regulatory approval work, the company explains.

Currently, Amgen is moving into a second round of field studies of its consensus interferon for the prevention of cattle shipping fever, and is carrying out human clinical trials of gamma interferon as a therapeutic agent for a range of cancers. The company also reports greatly increased sales of its line of recombinant peptides, including erythropoietin, interleukin-2, consensus and gamma interferons, insulinlike growth factor, and epidermal growth factor to biomedical researchers. In late July, Amgen formed a partner-

ship with Arbor Acres, a private supplier of chicken breeding stock in Glastonbury, Conn., to apply genetic technology to the breeding of chickens and turkeys.

At Bio-Response, total revenues more than tripled from second-quarter 1984 to \$1.1 million, fueled by a 978% jump in contract revenue to just over \$1 million. BioTechnica International reported a 229% increase in total revenues to nearly \$1.3 million, thanks chiefly to new research contracts. And DNA Plant Technology revenues rose 30% to just over \$1 million in the second quarter as the company signed on new research clients for a variety of projects.

Negative performance reports continued to be dominated by Genex, whose second-quarter revenues plummeted 41% from last year's second quarter to \$4.8 million and net loss swelled to \$2.3 million from \$2.0 million in the equivalent year-earlier period. The stricken company, whose all-important supply contract with G. D. Searle will expire and not be renewed next month, has lost \$4.7 million over the first six months of the year, far more than the \$3.6 million lost by mid-1984. Genex's stock price reached all-time lows in recent weeks and Genex now is trying to convert its Paducah, Ky., plant, which has been manufacturing L-phenylalanine for Searle under the soon-to-be-defunct contract, to a contract manufacturing facility.

At Molecular Genetics, revenues slumped 14% in the second quarter and were down 12% in the first half of 1985. Over the six-month period, sales of the Minnetonka, Minn., firm's two animal health care products—a test kit to detect *Escherichia coli* scours in calves and a monoclonal antibody treatment for the affliction—were little more than level. "There continues to be a shortfall in product revenues against our beginning of the year expectations," concedes Franklin Pass, the company's chief executive officer. In response, the firm reduced research, sales, and administrative expenses 15% from the budget plan during the first half and is taking steps to improve its marketing effort, Pass says. □

Bleak future predicted for petrochemicals

Forecasters of growth in U.S. demand for and production of petrochemicals see only a downward trend. Estimates of returns on investment, future capacity, and trade balances for petrochemicals also are heading downward. These views continue to be held by investors who for more than a decade have put relatively low values on the stocks of most major chemical companies.

A bleak outlook—but not without some bright spots—for petrochemicals in particular and for the chemical industry in general was painted by speakers at conferences on feedstocks and strategic planning for petrochemicals sponsored by the Energy Bureau in Houston earlier this month. Increased flexibility in use of feedstocks to make chemicals, a slow increase in the profitability of chemicals manufacturing, and a conclusion that the threat of new foreign competition has been overestimated were some of the positive assessments.

Over the next 10 years, smoothed curves for growth in U.S. ethylene demand will show annual rates of 1 to 2%, according to Joseph H. Posevina, manager of chemical services for Data Resources Inc. in Houston. Posevina estimates that consumption of the various derivatives of ethylene will reach 35 billion lb in 1994, up from just over 31 billion lb

in 1984. Polymers, made from ethylene or intermediates based on ethylene, will account for most of the growth in demand. Growth in demand for polymers actually will offset losses in demand for a half-dozen ethylene derivatives such as ethanol, acetic acid, and the chlorinated ethylenes.

The trade balance in ethylene—almost all in derivatives—will continue to decline steeply. But after about 1990, both the decrease in exports and the rise in imports will slow, moderating the decline in net trade. However, net trade will fall from a peak of about 4.8 billion lb of ethylene equivalents in 1983 to about 1 billion lb by 1995.

Posevina predicts that as a result of shifts in demand and in the net trade balance in ethylene derivatives, growth in production will be small and overcapacity will continue. Profit margins will remain weak as prices hold at levels well below those desirable for reinvestment.

The outlook for another important olefin made in steam crackers, propylene, is brighter than that for ethylene, according to Stephen N. Rothman, a vice president of Chem Systems. Not only will domestic demand for propylene grow faster than will demand for ethylene, but net trade in propylene derivatives will keep rising slowly and reach an annual level of more than 2.2 billion lb in the early 1990s. The amount of propylene required for alkylation, however, will continue to be the major factor determining propylene prices as changes in supply-demand relationships between propylene made in refineries and that made in steam crackers remain secondary in importance.

Butadiene's outlook depends almost entirely on U.S. automotive industry trends, Rothman says. Its supply will be determined by the kind of hydrocarbons fed to steam crackers, with the supply limited as long as the very light hydrocarbons get preference. In the long term, imports are expected to decline. Other C₄ hydrocarbons will be dehydrogenated to make butadiene as supply and prices dictate.

Refineries will remain the main supplier of major aromatics for chemical use, says Merritt G. ("Red") Marbach, who is a business research manager for base chemicals at Shell Chemical. More than 70% of aromatics—benzene, toluene, and mixed xylenes—used in making chemicals come from catalytic reforming in refineries, with about 25% coming from pyrolysis gasoline produced in steam crackers, and the rest coming from coking coal.

Costs of aromatics, which chemical users will have to pay, likely will be higher, reflecting the increased costs to refiners of replacing lead alkyls—which are being phased out of gasoline by the federal government—with other sources of octane value. Already the marginal costs of increasing the octane value of gasoline have risen from about 0.6 cent per octane number per gal in 1984 to 0.8 to 1.0 cent today. As the lead phasedown is completed, additional increases to 1.0 to 1.2 cents may occur. These marginal octane costs reflect the assumption that the mixture of gasolines offered, generally a regular and a premium, will have an average octane value of 88.8 to 89.0. The change in marginal octane costs from 0.6 cent per octane-gal to 1.0 cent increases the value of the toluene and mixed xylenes in the refinery gasoline pool 7 to 8 cents per gal. Should marginal costs rise to as much as 2 cents per octane-gal, the increase in value of these aromatics would be 26 to 27 cents per gal.

The changes made during the early 1980s in steam crackers to allow use of all kinds of hydrocarbons are helping the petrochemical industry's competitiveness, says Richard L. Baldwin, vice president and general manager of Union Carbide's hydrocarbons department. By having the flexibility to shift between ethane-propane mixtures and naphtha and gas oil, olefin-producing plants will remain more efficient than units without such flexibility. About 80% of the U.S. ethylene industry has light feedstock flexibility, and about 55% of the industry can handle naphtha and gas oil. The inflexible steam crackers, often uncompetitive now, are likely candidates for shutdown. □

U.S. demand for ethylene will grow slowly for another decade

Product	Ethylene consumption (billions of lb)				
	1974	1979	1984	1989	1994
Linear low-density polyethylene	0.0	0.2	2.4	3.8	4.9
Low-density polyethylene	6.3	7.9	6.2	5.1	4.4
High-density polyethylene	3.0	5.3	6.3	7.3	8.3
Ethylene oxide	4.4	5.4	5.2	5.3	5.5
Ethylene dichloride	3.3	4.4	4.3	4.7	5.0
Ethanol	1.0	0.9	0.7	0.3	0.0
Vinyl acetate	0.4	0.7	0.7	0.8	0.9
All other	2.6	3.0	2.9	3.2	3.4
TOTAL	22.9	30.0	31.0	33.0	35.0

Source: Data Resources

More scientific news from
the Chicago ACS meeting

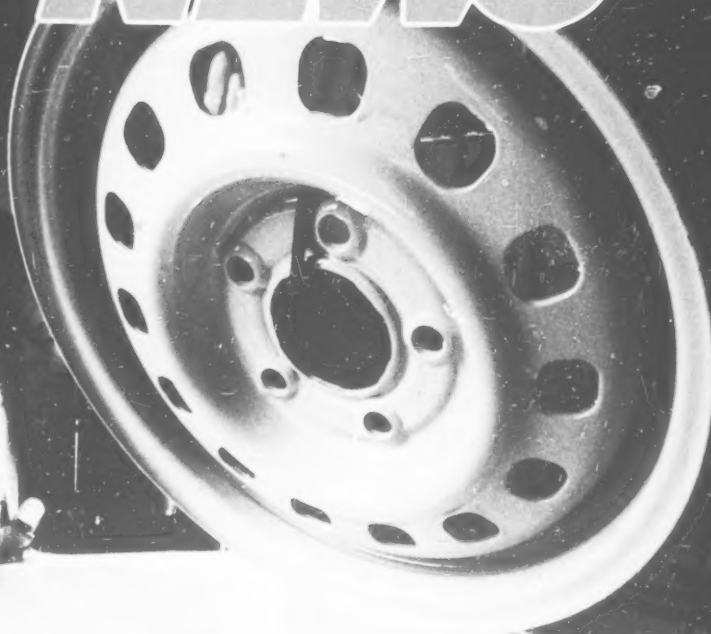
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COMING

Industry faces new global
challenges Page 27

News of the Week

■ **Harvard researchers identify angiotensin, a protein that induces new blood vessels to grow in living tissue.** Page 6

■ **Two reports add more fuel to the ongoing debate over technology export controls.** Page 7

■ **Guidance document for research proposals to use genetic engineering techniques on humans has been approved.** Page 8

■ **Administration appeals court ruling that orders EPA to control sulfur dioxide emissions from midwestern utilities.** Page 8

Business

Capital spending in the U.S. chemical industry is ahead of last year and may surpass goals set earlier. Page 10

Government

Current U.S. policy on technology, economic competitiveness, and trade criticized by Commerce Department economist. Page 12

Science

From ACS meeting: solid-state synthesis of new materials; albumin complexes in enzyme therapy; electron ejection from anions; novel complexes for conductive polymers; ethics in chemistry. Page 15

Education

NSF's program to provide four-year colleges with money to buy instruments awards \$5.5 million in first year; college chemistry lab coordinator gives money-saving tips. Page 25

Technology

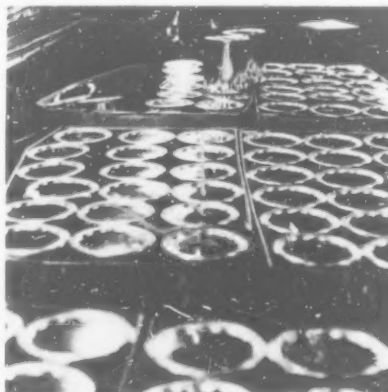
From Chicago: biotech research for agriculture; eastern oil shale economics; gas sensor development; low-cost FTIR spectrometer; selective Fischer-Tropsch catalysts; radiation-sensitive polysilanes; bioaccumulation of soil cadmium and lead. Page 71

ACS News

Councilors adopt a new procedure for setting subscription prices, attend to other business matters in Chicago. Page 78

Cover: Photo courtesy of SCM's Glidden Coatings & Resins division

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Product Report

Paint and coatings firms are taking on a more global look, acquiring other companies in their product area to face geographically shifting markets. Page 27

Chemical Capital Spending Up Slightly

Capital spending in the U.S. chemical industry appears to be slightly ahead of last year's and may be ahead of spending goals set at the beginning of the year.

According to a C&EN survey of 10 large chemical companies, spending in the first half of 1985 totaled \$1.58 billion, up about 5% from first-half 1984. However, at the end of 1984, these same 10 firms had budgeted an estimated \$3.63 billion for all of 1985, less than 4% more than they actually spent in 1984.

More significant, in the first half of this year, the companies had spent 43% of their planned budgets. In the same period last year, they had spent 41% of their estimated budgets for the year and 43% of their final spending. Since capital spending in the second half tends to be higher than in the first half, this would indicate that final spending for 1985 for these companies could end up at least equal to, if not higher than, they originally planned. However, a widely forecast slowing of the economy in the second half could negate that, with chemicals following the rest of the economy in pulling in the capital spending horns for the remainder of the year.

The modest annual increase in capital spending by these chemical

companies is at variance with capital spending in broader surveys, but in different directions. Capital spending in the manufacturing sector has been steaming along for the past year but is expected to slow now. The Conference Board's survey of capital spending for all manufacturing shows a first-half increase of almost 18% over the same period of 1984. However, the survey by the New York City-based business research group shows that capital spending in chemicals and allied products in the first half totaled \$5.3 billion, an almost 3% decline from the same period last year.

It is not surprising that capital spending in the chemical industry has been lackluster, compared with the rest of the economy. The government estimates seasonally adjusted capacity utilization for chemicals at about 78%, a figure that may well be too high, according to industry sources. They say that the overhang of shutdown chemical plants that could be restarted if demand were to justify it could put capacity utilization even lower if they were counted.

This overhanging capacity is also serving to depress chemical prices, thereby keeping returns on plants below reinvestment levels, further

depressing the capital spending picture. Pricing could be complicated even more by a slowing in demand in chemical end-use markets and also could slow the need for any new capacity in the second half.

There are warning signs looming. According to the Conference Board analysis of its broader survey of all manufacturing, in spite of a brisk increase in capital expenditures in the second quarter over the first quarter, capital appropriations (monies allocated to be spent in the future) by the country's 1000 largest manufacturers were down.

Douglas Cliggott, director of the survey for the Conference Board, says, "Latest survey findings now suggest little, if any, growth in capital spending over the next two quarters. The anticipated slowdown [in capital spending] will clearly make it more difficult for the economy to achieve a strong rebound in the second half of this year."

The Conference Board survey shows the same situation in the chemical industry as in manufacturing as a whole. While capital expenditures for chemicals and allied products in the second quarter were increasing 10% from the first quarter to \$2.80 billion, capital appropriations were dropping almost 12% to \$3.01 billion.

The Conference Board survey also shows another problem in backlogs (monies appropriated, but as yet unspent). That figure ideally rises, indicating an increasing amount of money in the pipeline. However, in the second quarter the backlog for chemicals and allied products fell almost 1% to \$8.44 billion from first-quarter figures.

Thus, although there are slight signs that a few major chemical companies may finish the year with modestly good capital programs, chances are that for the industry as a whole, capital spending is going to remain sluggish just as it has for the past few years.

William Storck, New York

Chemical spending in first half is up 5% from last year

\$ MILLIONS	First-half capital spending	Earliest full-year estimate	% annual change first half	% of full-year budget spent in first-half 1985	% of full-year budget spent in first-half 1984	First-half spending as % of total 1984 spending
Air Products ^a	\$ 138	\$ 325	21%	43%	36%	44%
Celanese	81	200	42	41	33	34
Dow Chemical	348	830	14	42	41	39
Ethyl	43	116	-14	37	53	49
W. R. Grace	179	420	2	43	39	46
Hercules	96	210	4	46	46	42
Monsanto	293	575	7	51	46	45
Olin	49	170	-5	29	30	32
Rohm & Haas	64	130	15	40	43	41
Union Carbide	286	650	-12	44	42	48
TOTAL	\$1577	\$3626	5%	43%	41%	43%

^a For first half of fiscal year.

Paints and Coatings: The Global Challenge

Patricia L. Layman, C&EN London

The woes facing the paint and coatings industry have been around for years: market maturity with slow growth; highly fragmented markets, served by thousands of competitors worldwide; shrinking end-use markets that further retard growth; shifting patterns of consumption from one set of historically comfortable geographic areas to other, developing areas.

What to do in such a situation? Turn to marketing, the gurus would advise. Fight for market share, to gain a point or two in the business, to help increase production, improve economies of scale, and boost profit margins. The easiest way to gain market share has always been to buy into the business, acquiring other suppliers (and, not necessarily coincidentally, reducing the competition).

Such acquisitions therefore have been a standard feature of the indus-

try for years. In the U.S., for example, the number of coatings manufacturers has declined, primarily because of mergers or acquisitions, from 1500 in 1967 to just over 1000 today. In the U.K., as another example, there have been similar reductions: Where there were about 500 paint makers in the 1950s, there are now only about 250 to 300 producers.

For a long time, however, except for a few small and isolated incidents, such acquisitions were domestic. But in the past several years, there has been a decidedly interna-

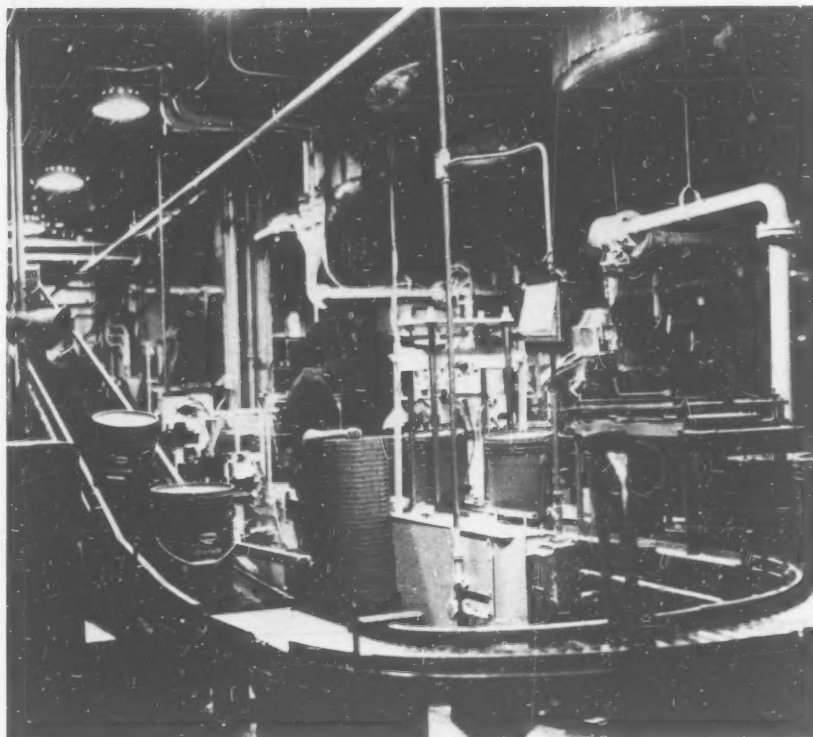
tional tinge to the buying binge. Some examples:

- Last month, BASF closed its purchase of Inmont, the Clifton, N.J.-based maker of printing inks and coatings, from United Technologies. BASF outbid Akzo, the Dutch chemicals giant, its major serious rival for the purchase.

- Akzo had wanted Inmont to add to its U.S. acquisitions last year of Wyandotte Paint Products, Sikkens, and Bostik's coatings operations.

- PPG Industries in 1984 bought the automotive paints unit of Lack-





Five-gal filling line at Glidden's trade sales paints plant in Huron, Ohio

werke Wülfing in West Germany, and consolidated its holding in Peintures Corona, probably the second-largest paint maker in France, going from 62% to full ownership.

- Imperial Chemical Industries last year bought Cie. des Vernis, the

largest French paint maker. At the same time, BASF bought Valentine's U.K. operations.

- Tikkurila Värитеhta, a subsidiary of the Finnish chemical company Kemira Oy., bought the London-based paint producer Donald Mac-

pherson, the fourth-largest U.K. paint manufacturer.

- Wilhelm Becker, a Swedish company dominant in the Scandinavian market, and outbid for Macpherson by Tikkurila, promptly acquired 75% of Goodlass Wall, the U.K.'s sixth-largest paint maker, which also has capacity for making resins and powder coatings, and the British rights to the U.S.-owned Valspar label, in the trade and decorative paints market. It already had acquired Conway Coatings in Britain, Lackwerke Wülfing in West Germany, and Bichon in France.

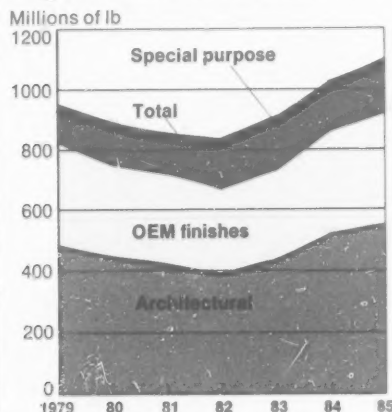
There were other mergers and acquisitions, too, of course, in strictly domestic markets. In fact, a quick survey of acquisitions in the U.S. alone points up that, between mid-1979 and mid-1983, there were roughly 50 to 55 acquisitions in the paint and coatings industry. From mid-1983 to mid-1985, however, there have been 73. Among the major ones were Clorox's acquisition of the Lucite name and manufacturing from Du Pont, to add to its own Olympic Stain division, in June 1983; last year's purchase by Valspar, of Minneapolis, of Mobil Chemical's U.S. and Canadian coatings operations; and last month's acquisition by RPM of Carboline, the industrial coatings unit of Sun Co., based in St. Louis.

The pattern of acquisitions has been changing somewhat, moreover, points out Stanley T. Pender, manager of business planning and marketing research at SCM's Glidden Coatings & Resins.

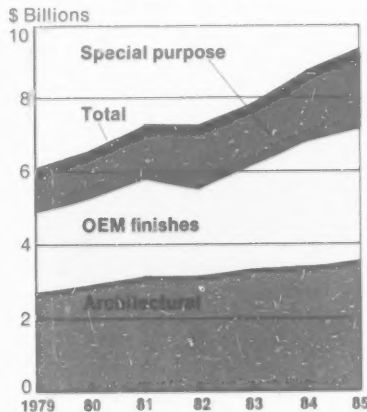
"Lately, the acquisitions have been divisions, or pieces of companies, as well as the small independents. Companies seem to be adjusting their technological strengths," selling off what doesn't fit their business portfolio strategy, and trying to build what will enhance it.

For example, Inmont recently sold its wood finishes business to Reliance Universal, a major in that field. Becker sold the automotive operations at its West German acquisition Wülfing to PPG, which is strong in that field. At about the same time, PPG also picked up the automotive coatings business of International Paint, leaving the British producer to concentrate on ma-

Architectural coatings have largest share of volume ...

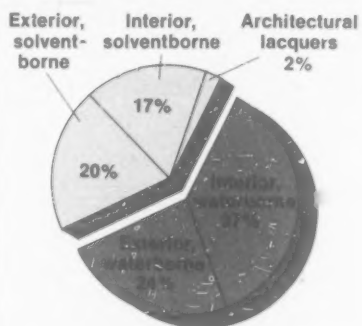


... but OEM finishes have taken the lead in value



Note: The three major types of paints and coatings, according to the Bureau of the Census, are defined as follows: **Architectural coatings**—includes stock type or shelf goods formulated for normal environmental conditions and general applications on new and existing residential, commercial, institutional, and industrial structures. **Product coatings for original equipment manufacturers (OEM)**—includes coatings specifically formulated for OEM to meet conditions of application and product requirements and applied to such product as part of the manufacturing process. **Special-purpose coatings**—includes coatings that also may be stock type or shelf goods but that differ from general architectural coatings in that they are formulated for special applications and/or special environmental conditions, such as exposure to extreme temperatures, chemicals, and fumes. Sources: Bureau of the Census, C&EN estimates

Waterborne formulations lead architectural coatings



rine coatings, which it dominates worldwide, and other technologies in which it has strengths. ICI sold its business for heavy-duty paints for agricultural, construction, and earth-moving equipment to Donald Macpherson. Du Pont was divesting itself of decorative coatings when it sold Lucite to Clorox, to concentrate on its remaining, industrial- and automotive-oriented businesses. And Mobil and United Technologies now are essentially out of the paint business altogether.

"Companies are no longer being embarrassed about not being all things to all people," adds Pender. "We are all devoting ourselves to some technologies, and not to others."

Which technologies to devote a company's efforts to has, therefore,

become a major point for contemplation in paint companies. The contemplation is also complicated by the fact that most of the business has become a global business. It is global because, in many areas, its customers are competing in global businesses.

"We have to react to the situation as it exists," says Malcolm G. Slaney, group vice president for PPG's coatings and resins division. "We are competing today on a world basis. But the paint industry is not the only one which is—all our customers are also competing on a global basis. Anytime somebody thinks we are competing in Pittsburgh, or in Pennsylvania, or even on the Eastern Seaboard, he's crazy."

Brian Letchford, executive director of ICI's paints division, Slough, U.K., would agree with that assessment, with a particularly British outlook. "ICI was archetypical of England and the British Empire," he points out. "Our 25 paint companies around the world would superimpose on an old map of the Empire and Commonwealth. We had incredibly extensive coverage. But about 10 years ago, we recognized that we had a relatively limited presence in Europe, and none in the U.S. or Japan. That concerned us, and we figured we would have to be worldwide."

The major reason paint and coatings companies figure they have to be worldwide marketers is because their markets—their customers

West Germany is largest paint producer outside U.S.

	1984 production (thousands of metric tons)	% change from 1983
West Germany	1321	1.0%
Japan ^a	1247	-0.1
France	809	-3.0
U.K. ^b	670	3.1
Italy	625	-0.8
Spain	278	-2.5
Netherlands	253	5.3
Sweden	189	-1.5
Denmark	133	7.6
Belgium	131	2.4
Austria	126	5.0
Portugal	92	0.7
Finland	82	4.1
Switzerland	82	3.8
Norway	75	1.8

^a Data for 1983; per cent change from 1982. ^b Production in millions of liters. Sources: European Federation of Paintmakers' Associations (CEPE), Rauch Associates, C&EN estimates

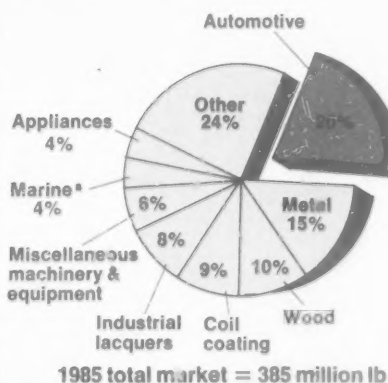
—are going that way, too. Perhaps the best example is the automotive industry.

A study of the paint and coatings industry, published earlier this year by Commack, N.Y.-based consultants Business Trend Analysts, cites some of the problems facing the U.S. motor vehicle industry and their impact on the paint and coatings industry. "Squeezed [by] high interest rates, a rapid rise in foreign imports, and an extremely long and deep recession, domestic manufacturers saw production of trucks, buses, truck trailers, and automobiles drop sharply during the early 1980s. ... The market advances made by foreign competitors, principally Japanese manufacturers, are considered virtually irreversible." In fact, the report adds, foreign manufacturers will garner a larger share of the domestic auto market during coming years.

The BTA study addressed only the U.S. motor vehicle industry. But the same woes also have struck the European industry—imports are taking more and more of the business away from domestic producers.

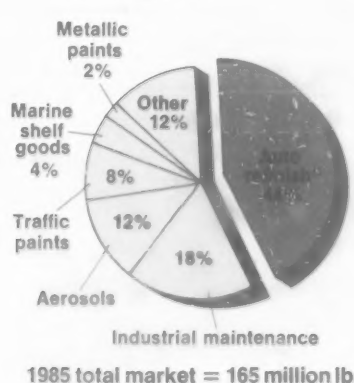
These problems affect the paint and coatings industry in two ways. First, quite simply, the fewer cars produced in the industry's country the fewer cars requiring coatings, and the market shrinks. Second, and

Automotive dominates a diverse OEM finishes market ...



^a Excluding shelf goods. ^b Primers, undercoats, paints, and lacquers. Sources: Business Trend Analysts, C&EN estimates

... and special-purpose coatings, too





Allen (above left): appliance makers going global. Pender (above): pattern of acquisitions changing. Wagner: home-center sales very important



more of a challenge, production is moving away from areas the industry is used to dealing with. Hence, the industry is beginning to move into such areas as Taiwan, Singapore, Malaysia, and Egypt.

Sometimes the moves must be from scratch. State-owned auto production companies, for example, present coatings suppliers with a clean slate. Other times, it is long-time customers who are expanding production into new areas. For example, General Motors reportedly is negotiating with the Egyptian government to produce automobiles in

that country, probably by consolidating and running the indigenous operations already there. If that indeed comes through, paint companies probably have legitimate reason to believe that GM will take along with it one of the paint companies it works with in the U.S.

There is no reason to think that the GM deal would be the last of its kind. Instead, the possibilities are most appealing for the industry. And it is that kind of optimism—looking at the end-use market as a growing global one, rather than a shrinking domestic one, that has paint and coatings companies working to build their market shares.

Autos are one such area; others include appliances and furniture manufacture and finishing, both of which are increasingly moving into nontraditional geographic areas. Appliance manufacturers are going international, points out Glidden's Alan W. Allen, vice president of industrial coatings, and "they seek world-class suppliers." So, too, do many of the furniture makers from the U.S. Southeast, for example, who now do significant amounts of manufacturing in the Far East, importing back into the U.S.

So, the trend is clear. "We may not

have a world car yet," says PPG's Slaney, "but we're going to have a world paint" ready for when it comes along. Other major companies would agree, and are doing the same work to meet customer demands.

Large companies can afford the developmental and applications work, the toxicological testing, and the environmental/worker safety testing needed. Smaller companies, however, will not be able to support that kind of effort, to compete for the large end-use markets such as automotive or appliance coatings. "Nichers" will meet the demands in small, specialized areas that are too dinky for the majors to bother with. Assuming they can build a dominant share of that specialized market, they can do quite well, particularly without the overhead of a big paint company or corporate surroundings. European industry observers, for example, cite as an impressively successful nicher the West German coatings company Weilburger Lackfabrik, which has grown both internally and from acquisitions of other small companies 517% in nine years, to roughly \$35 million per year.

Hans-Harald Grebe, owner and director of the firm, says, "Private ownership means we can spend two or three years [developing the market] without having to worry about profits and what the stock markets think of us. If you find the right niche, and attack it properly, you can then take that niche worldwide." And customer development, he adds, is built up directly at the executive level, with his personal commitment.

Whatever the size of the company, however, what is clear is that "what we can't have anymore is 10 different companies competing for a piece of the action in a given industry," says ICI's Letchford. "The British car industry, for example, used to be supplied by nine companies—[now] it is four or five. That's the way the world is going."

All that is establishing a handful of international supercompanies ready to operate in the paint and coatings industry worldwide. There is a great deal of disagreement as to the ranking. An informal poll of

Product Report

five executives and industry analysts for this report wound up with six different rankings. The same names, however, kept popping up; in alphabetical order, BASF/Inmont, Glidden, Hoechst, ICI, PPG, and Sherwin-Williams.

The specific rankings also depend upon what segment one is speaking of. For example, in the U.S. market, the sales of paints to the consumer, do-it-yourselfer, are dominated by Sherwin-Williams, which has elected to concentrate heavily on this segment and other architectural coatings; De Soto, which produces the paint marketed by Sears, as well as other products; and Glidden. Glidden is especially enthusiastic about selling via home-center stores, such as the Builders Square units owned by K-Mart, which Glidden supplies. According to Thomas F. Wagner, vice president for trade sales, "Surveys show that, of all the people who go into these home centers in any 12-month period, 55%



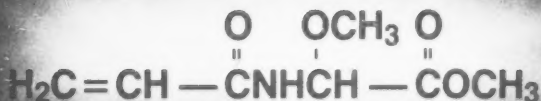
Slaney: competing on world basis

will buy paint. This market has begun to become very important."

ICI dominates the trade-sales segment in the U.K., with probably more than 30% of the business. It has boosted this significantly over the past year and a half, since it introduced a solid emulsion formulation that looks vaguely like cheesecake but which spreads like a normal liquid paint. Two years earlier, ICI had demonstrated that innovation also can come in marketing, when it introduced a line of "natural white" formulations—whites with just a hint of color in them. The British market had long depended upon white paints; brilliant whites in 1983 accounted for some 60% of the total retail market. The whites-with-color now account for some 20% of the total retail paint market, much carved from the plain whites, but the rest taken from colors.

PPG has suffered a significant slide in market share in the U.S. retail segment. Partly, it is a matter of strategy. According to the 1984 annual report, PPG's strategy "is to provide one quality of product—PPG's best—for discerning do-it-yourselfers. Advancing PPG's strategy in 1984 was penetration of the home-center market, with several quality regional chains stocking Pittsburgh Paints products for their upscale customers." But it is also clear that the coatings division man-

Industrial coatings continue to be strong growth area for paint makers



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Beverage and food containers make wide use of waterborne coatings

agement is less than obsessed with consumer paint sales. When the subject came up, Slaney seemed somewhat surprised, discussed the topic briefly, and then returned with much more enthusiasm to the subject of industrial coatings.

Certainly, PPG plays a much more significant role in industrial coatings. Glidden is also a major in the field, as is Du Pont, Valspar/Mobil, and internationals including ICI, BASF, Hoechst, Akzo, and International Paint.

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Within the industrial coating market, companies concentrate on their specialties. International Paint, for example, is by far the leading producer of marine coatings, supplying from its U.K. headquarters and various other plants around the world a market that has largely shifted to the Far East and the Middle East.

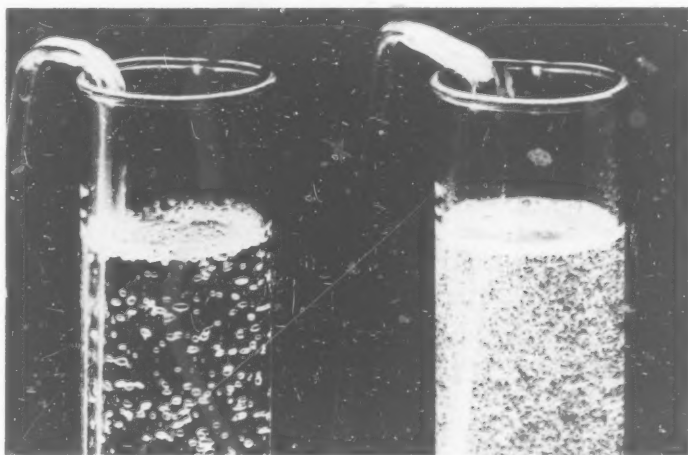
Glidden is probably the leader in powder coatings, having built on the technology it acquired years ago from Celanese. Its powder coatings business grew nearly 55% in volume from fiscal 1983 to 1984, and last June the company finished an expansion that will increase powder capacity 50% at its Charlotte, N.C., plant. By one estimate, consumption of powders last year was just over 50 million lb. One of the major applications is tops and lids of washing machines, replacing the traditional porcelain frit coatings; Glidden worked with Whirlpool Corp. to develop a satisfactory formulation.

This kind of cooperation between coatings makers and customers is becoming more and more the rule, not the exception. Customers want formulations to work on their products. For new technologies, coatings makers even will help train workers in application techniques.

With customers putting increasingly more pressure on paint and coatings suppliers to give consistent service worldwide, there is, unsurprisingly, a concomitant need for worldwide service from paint makers' raw material suppliers.

Raw materials are highly important to the paint and coatings industry. According to an analysis done by the Paintmakers Association of Great Britain, raw materials and containers account for 56% of the average paint manufacturing costs. The association points out that the proportions "can vary significantly indeed according to the type of product and market area." But the low end of the range is probably about 50%, and raw materials can easily run up to 65% of total paint manufacturing costs.

To some extent, paint and coatings producers help control raw material costs. As ICI's Letchford notes, "Most major paint companies produce their own resins," a major con-



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ICI builds a market on "temporary"

It was a splashy press briefing that Imperial Chemical Industries' paints division held in London earlier this month, complete with a showpiece Aston Martin, the car of James Bond fantasies, worth a cool \$75,000.

But it was also a serious message that ICI was presenting, in officially introducing Tempro, a family of temporary protective coatings it has been developing over the past four years. The Tempro systems are being touted as a major advance in the protection of special surfaces, such as the paintwork of new cars, untreated metals in temporary storage, plastics, and similar materials. They are also finding use as temporary coatings—as temporary highway marking paints, for example, and camouflage coatings.

The main-volume market for such coatings is the automotive industry, and ICI started its work with that industry about two years ago. "We developed the system alongside the car makers—it has to be compatible with their manufacturing systems," recalls one marketer at the company.

Tempo systems are aimed at the protective coatings already applied; for example, by car manufacturers that

coat the cars to protect them against damage in transit between plant and dealer. The dealer then strips off the protective coating, preparing the automobile for purchase. Auto makers sometimes do this in the U.S., but in Europe, it is nearly always done.

Current coatings are wax based and must be stripped with solvents. That can pose environmental problems—how to dispose of the solvent strippers—and worker safety problems, given the flammable nature of the solvents used as strippers.

Those are major weaknesses ICI is hitting at with Tempro. Their coatings are water based, washed off with aqueous stripping compounds that can be flushed directly down the drain. ICI won't say all that much about the chemistry of the systems, but it does disclose that the Tempro coatings are based on a patented water-based acrylic copolymer system that forms a transparent film lasting up to a year; the removers are based on mild solutions of organic and inorganic alkaline compounds that can be used with hot or cold application methods, on any combination of surfaces. Each car uses about 1 L of Tempro.



Worker strips off Tempro in preparing car for purchase

So far, ICI can count as auto-making customers BL (formerly British Leyland) with its Mini, Metro, and Rover vehicles; Jaguar for all export models except to the U.S., and it is currently evaluating use for U.S.-bound models; and Aston Martin. According to the technical director of Aston Martin, who says he personally test-drives each car before it leaves the plant, the coating helps protect against stone damage. This "can be considerable at the 170 mph we test-drive them at," he points out.

And because European dealers are accustomed to protective coatings, ICI Americas' commercial development staff is promoting the system, under the tradename Belpo, to U.S. manufacturers who are exporting vehicles. (The Tempro name had already been registered in the U.S.)

ICI isn't looking just at the automotive area, however. Because the coating can be formulated to a matte, colored condition, it is also useful for paints of various types, needed for temporary applications. Some potential markets are rather larkish—marathon-running markings on roads, for example, or perhaps green stripes for St. Patrick's Day parades. Others are of military significance—providing changing camouflage coatings for tanks and other military vehicles in Scandinavia or Canada, perhaps—like so many mechanized ptarmigan or snowshoe hares.

Temporary coatings to highlight surface metal defects prior to finish-coating are a market the company is working to develop for automotive and other motor vehicle manufacturers and other industries using large pieces of sheet metal. The special version of Tempro is black-pigmented, to give high gloss and reflectivity to highlight minor surface faults. The coating can then be removed in the existing metal pretreatment cleaning stage already carried out prior to painting.

stituent of the formulations. PPG, for example, produces about 80% of its resins. Partly that is to ensure constant, controllable supply. But it is also a way for a paint company to keep proprietary technology—often the key to a formulation's success—proprietary. As PPG's Slaney

puts it, "Our business is polymer R&D, and if you have people making the polymers for you, there go your secrets."

That leaves only some of the more commodity-type resins and the other major coatings constituents, such as solvents, and pigments, to buy.

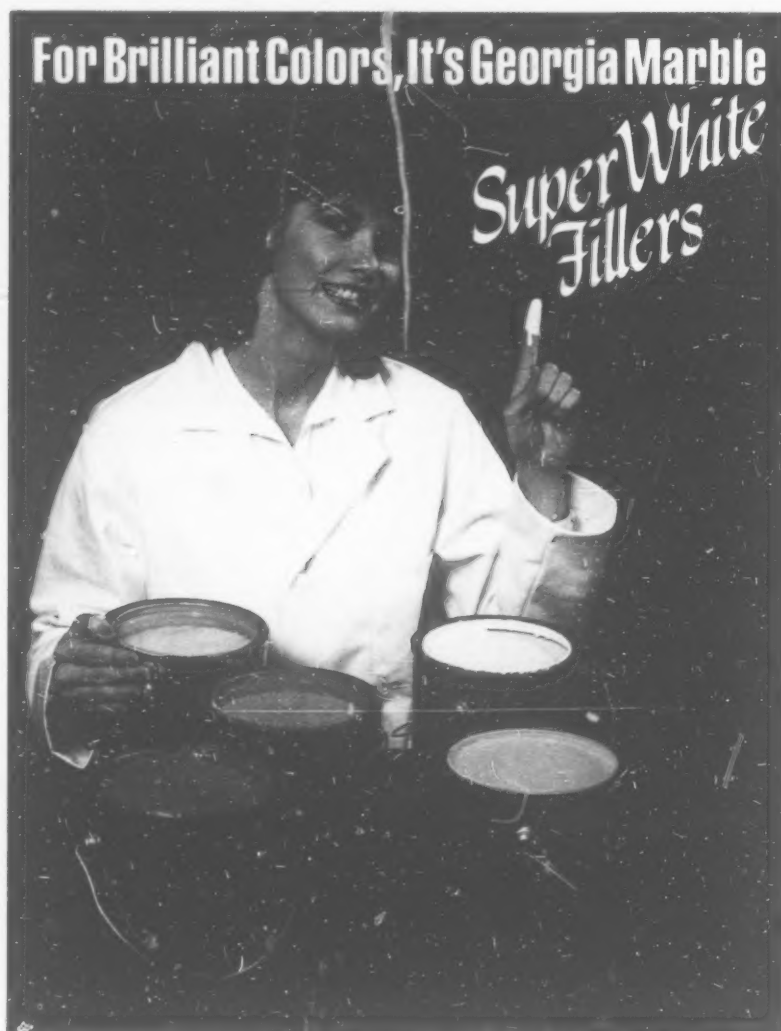
And buying has become an increasing challenge, as raw material prices have risen faster than the selling price of finished coatings and paints.

Data pulled together and estimates by Business Trend Analysts show that clearly. However, the

broaden the base for a raw material supplier's selling, the better the possibility of helping control costs and subsequent price hikes passed on to the paint and coatings industry. BTA is somewhat encouraging about future price rises. "Although by 1984 prices of some materials, notably those of inorganic pigments, began to increase alarmingly," it notes, "the outlook remains

fairly bright. Increasing downward pressure on crude oil prices should keep price increases of resins and solvents to modest levels for the next several years, while the depressed state of American agriculture portends continued weak prices for farm products such as vegetable oils."

The materials that paint makers buy have been selected for particu-



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CIRCLE 60 ON READER SERVICE CARD



Growing number of do-it-yourselfers has spurred trade paint sales

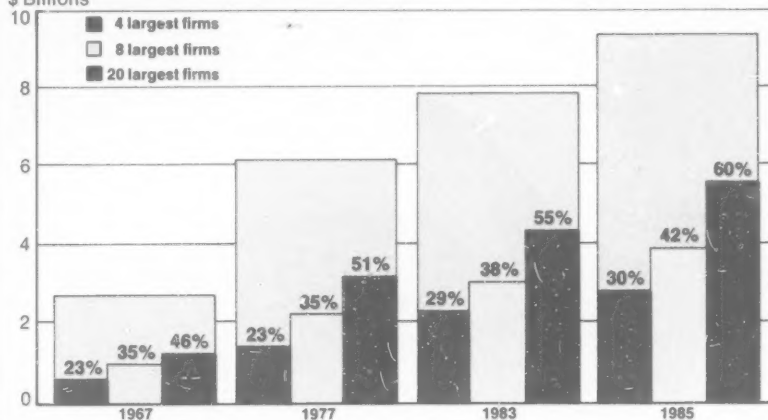
lar specifications for incorporating into particular formulations. As those formulations find their way around the world, then, the raw materials purchased around the world still must meet the same specifications. If the same company is supplying a product worldwide, the chances are that much better that the specifications will be the same—just right for the paint or coating formulation. Increasingly, the result is that paint makers are writing world contracts with suppliers.

Executives at Exxon's Essochem Europe operations, for example, support that conclusion. "If we can guarantee the same solvents, for example, with the same specifications, it is an advantage to us," says one. The tie-ins are also attractive: "Our special link with PPG in the U.S. will help us as they expand in Europe," he points out.

"Smaller competitors I am sure are finding it more difficult to keep pace with the changes in the marketplace. Through the 1970s, there were national markets, with many different grades of products. There has been a change—fewer grades,

Largest U.S. paint companies are accounting for larger portion of industry shipments

\$ Billions



Sources: Rauch Associates, C&EN estimates

more international. We are rationalizing production," adds the Essochem official, "to produce fewer grades with more consistent specifications and quality worldwide."

The specifications have to satisfy the paint maker and, of course, the end-use customer in the long run.

Also, it will help as every firm in the chain becomes more adept at addressing international markets.

However, although going after international markets may be increasingly important to the paint and coatings industry, it is not everyone's cup of tea. There are dif-

Product Report

ferent ways to accomplish the same results, some companies argue, and there are pitfalls for companies who aren't used to mixing national cultures, for example.

A case in point is Tikkurila, the Finnish paint maker that last year acquired Donald Macpherson in the U.K. Tikkurila is Finland's largest paint producer, with nearly half the domestic and with strong Scandinavian sales. Total sales were about \$84 million in 1984. Macpherson was nearly twice that size—1984 sales of about \$154 million. However, its profitability was low, less than 3% of sales in 1983 and 1984.

Tikkurila basically was buying distribution, in the U.K. and in the European Economic Community, especially important to it to help move out its universal tinting systems—colorant systems that can be used in a wide range of base formulations from nitrocellulose-based coatings to latex formulations—into trade and industrial coatings mar-

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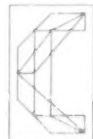
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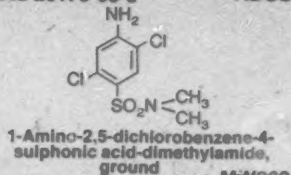
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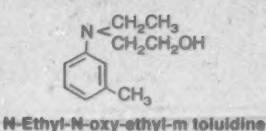
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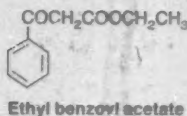
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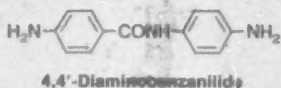
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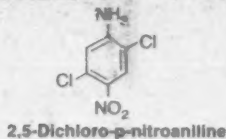
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kets, says Yrjö Sipilä, vice president of Tikkurila. "We couldn't grow much more in Finland," he says, "so we wanted to buy market share abroad, to broaden out."

The acquisition, however, has turned out more troublesome than anticipated. Pentti Sipilä, managing director of Tikkurila, has moved to London to devote himself to reshaping Macpherson, an indication that things haven't been so smooth as expected. And, in turn, many of the British employees have felt that the new management has not handled things well.

"The company was badly managed," concedes one former executive with Macpherson. "But that is not to say that all the management there was bad—and yet, that is what they seem to think. They have not handled their people well, and they are now losing many of them, whom they need. They don't yet have the international people-managing skills."

Glidden elected to go into the international business in another way, bypassing that problem, in Europe. The company had long been active in Latin America, first in Central America and later in both Colombia and Brazil. It is now one of the major paint producers in Brazil, which is saying more than most North Americans probably believe. Brazil is one of the top eight paint-producing nations in the world, according to the recently issued report on the U.S. paint industry by Rauch Associates, of Bridgewater, N.J.

In Europe, however, after three acquisitions in the early 1960s that turned out less than wildly happy, Glidden sold the three off and decided instead to concentrate on licensing. "We recognized that we had strong basic scientific knowledge of polymer chemistry," says G. Keith Brewin, vice president of international operations for Glidden division of SCM, "and we decided on the licensing approach to technology. Our management at the time decided the returns on their time were not sufficient to keep companies there."

In a few cases, the licensing has led to ownership—a minority ownership in New Zealand, for example—but basically, the company



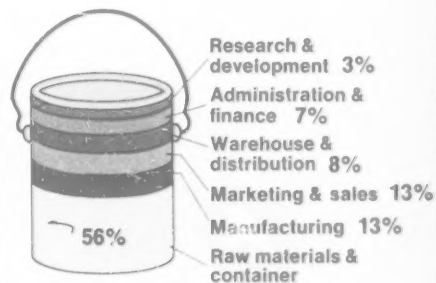
Brewin: chose licensing approach

concentrates on working with other technologically sophisticated paint makers as license partners. This is becoming increasingly difficult, acknowledges Brewin. Companies are becoming bigger, and medium-sized ones can't afford enough supporting R&D, nor do they have the scale to compete on price.

"This reduces the chances of an American company going in and working with a small company," he adds. "They have to be big enough to utilize your technology—if they aren't big enough, why work with them?"

Notwithstanding that, however, Brewin is convinced that the licensing strategy is sound. It has been refined over the past few years, he

Raw materials costs dominate typical can of paint



Source: Paintmakers Association of Great Britain

The giant oyster stirs a giant controversy

The giant, or Pacific, oyster *Crassostrea gigas*, is far from a humble creature. At its maximum size, 25 cm, it is larger than a standard dinner plate. It has, however, humbly found itself at the heart of an Anglo-Franco controversy over yacht-bottom antifoulant coatings that eventually may run through the industry worldwide.

Specifically, the controversy involves antifoulant coatings based on tributyl-tin biocides. Organotins are the latest in a series of biocides used in antifoulants, which go back thousands of years. The Phoenicians, for example, used copper on the hulls of their ships, more than 3000 years ago. Archimedes recommended a covering of lead sheathing, the Tudor Henrys ruling England opted for a layer of animal hair, covered with pitch. In this century, mercurial and arsenic compounds were the biocides of choice, as boosters to enhance the activity of copper, until they were forced out because of environmental concerns. They were replaced by the organotins, heralded as more efficacious and less toxic.

The key to these has been biocidal activity against seaweed and barnacles—"grass" and "animals," to the paint industry. This debris, settling onto the hull of a ship, can increase fuel bills significantly by hindering the passage of the ship through water.

For the past decade and a half, organotins have seemed the answer. They are less toxic to other living organisms, the argument goes, than mercury and arsenic, and more effective than copper. However, according to French researchers, organotins also have the unpleasant habit of hindering the growth of Pacific oysters. And that, to the French, is a serious matter.

France is by far the largest producer of oysters in Europe, and Pacific oysters have become increasingly important as a crop since they were intro-

duced from their homebeds in the Orient. They have been supplanting one of the mainstays of the French industry, the Portuguese oyster, and, indeed, are now called by the same name, *huîtres creuses*. When it was first suggested, then, that organotins from the antifoulant coatings had been leaching out, spoiling the oyster waters and causing gross deformation of the oyster shells, the French took the suggestion very seriously.

The controversy arises primarily because environmental regulators and marketers in other countries do not agree—at least, completely—with the French theory. The English company International Paint, probably the largest marine-coatings maker in the world, says that when the theory was announced, in 1981, the French authorities had no measurements of tributyl tin either in water or in oyster flesh. There was no evidence it was present in the environment, says the company. On the other hand, according to William Waldegrave, undersecretary of state for the U.K. Department of the Environment, "tributyl tin was detectable in both water and oyster tissues at all sites where the Pacific oysters had consistently failed to grow well in [the Ministry of Agriculture, Fisheries & Food] trials."

The question has gone to the European Commission, which has begun to study the problem. Given the glacial speed with which EEC usually acts, however, the authorities in France and Britain have each acted, but in different ways.

Final draft regulations have not yet been issued by the British government, but it is likely that the regulations will limit the retail sales of certain organotin antifoulants, drawing distinctions between the two types now being made. The earlier developed coatings are simple mixtures of coating and tri-

butyl tin, stirred in, in effect. In the newer products, the tin is bound into the copolymer resin making up the coating. International Paint officials expect the weight of metallic tin in the dry copolymer film to be limited to 7.5%, and the weight of metallic tin in the dried film of the older-type coatings to be limited to 2.5%—a weight low enough to ban such coatings effectively. And the limits will be only for pleasure craft, boats less than 12 meters in overall length; commercial vessels will not be affected at all.

In France, although it is still legal to make organotin antifoulants and to sell them, it is illegal to use them, except on exempted vessels—boats made out of aluminum alloy and all vessels more than 25 meters in length. However, International Paint, which says it is the brand leader in France, still sells organotin paints there—"far more than the amount needed for exempted vessels," says one marketer. "It looks as though people are ignoring the law."

More worrisome, paint researchers feel, is the tendency of people to experiment with biocides that are relatively untested. Copper, on its own, is not very effective; hence the tendency to boost its performance with mercury or arsenic compounds. At least one source says that mercurials have appeared again in some French antifoulant formulations.

Meanwhile, in the U.S., environmentalists have begun following the controversy. Coatings marketers have been heartened by an environmental assessment done by the Navy, to the effect that there is no significant impact on the environment from the Naval surface fleet using organotin antifoulants. It is a continuing program of investigation, however, and will be reviewed in another two years. The assessment said, however, that there is a great deal regarding the antifoulants that is unknown, so that more research and tests are needed.

says, as licensees select more. "They don't want everything, but are more selective, choosing the technology that will give them a time lead." The company is also starting to see exchanging of technological skills in another way, he believes: "Companies are saying, 'Maybe we won't do

the R&D, we'll let Glidden do it, and get the second generation.' There is some cross-fertilization—we're good at this, you're good at that, so let's work in a cooperative venture." That is difficult if both companies are competing in the same marketplace. So, according to Brewin,

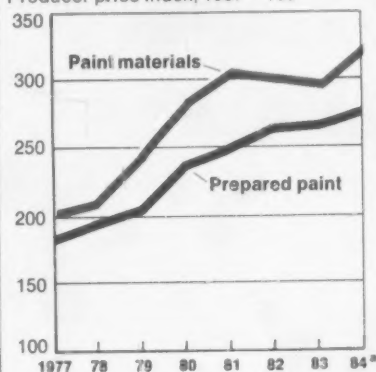
"Glidden is in an ideal position—our hands are not tied. We have the licensees but not the investments."

Both ICI and PPG, however, have opted for direct investment.

ICI has long operated internationally, as it followed the Empire

Raw material prices outrun paint prices

Producer price index, 1967 = 100



^a Estimate. Sources: Bureau of Labor Statistics, Business Trend Analysts

and stayed with the Commonwealth. It is now working to fill in the gaps. The acquisition of Valentine in France was a buying of both market share and an outlet for new technology, according to Letchford. "We already had a small company in France which was fairly strong in can coatings, industrial coatings, and powders. But this was not the mainstream position we wanted to be in. There was Valentine, espe-

cially strong in decorative paints and refinishing, and there was Valentine available. It made sense in terms of broad strategic development."

That was particularly so because both ICI and Valentine are so strong in the decorative side of the business, selling architectural coatings. These are still basically national or regional markets, most industry observers believe. As Letchford puts it, "I would be surprised to find a continental European decorative paint. We would find it difficult to package our Dulux, for example, and send it to France." However, the new market area expands the potential for new technology: "We developed the solid emulsion technology in the U.K., and sold it here. But we are also selling it now in France and West Germany—you can take knowledge across borders."

A strategy for global development also has shaped PPG's increasingly aggressive international push. The company had had tentative international operations—in Toronto—since after World War II, then built a plant in Mexico City. About 18 years ago, the company went to Europe, buying a small company in

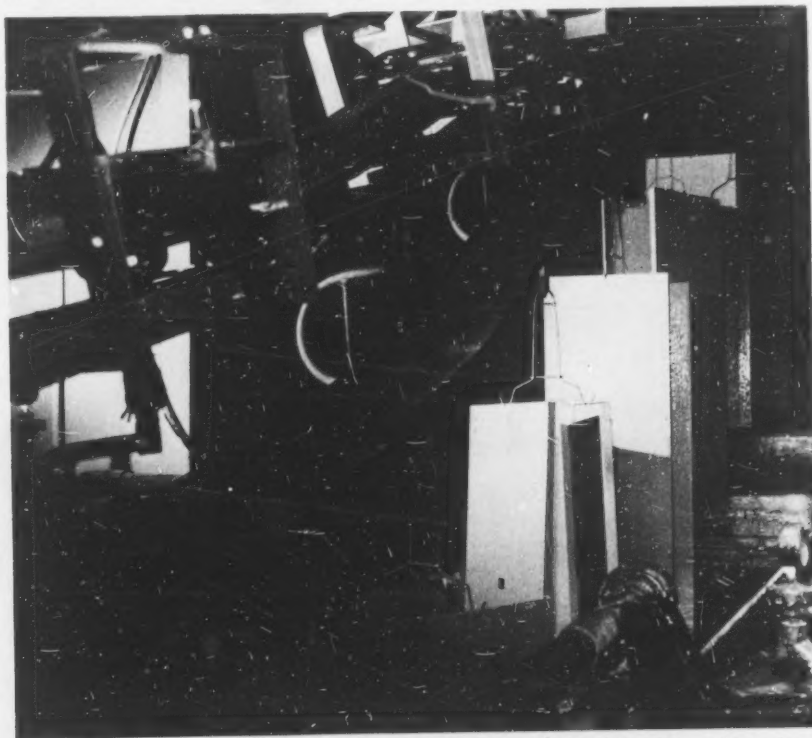


Electrodeposition bath at auto plant uses PPG Industries cationic coating

France, and then an interest in an Italian paint manufacturer.

But all that time, says Slaney, "we didn't take advantage of having a large paint company. We had a series of small paint companies. We had no special strengths, just the presence. We couldn't say to Ford in Dearborn, 'Look, give us the specs, and we can supply it around the world.'" A growing awareness, however, that ultimately a company would have to be able to say just that, led the company to its determination to move into global markets.

As ICI's Letchford contends, it is important for all paint companies to sit back and look carefully at what their strengths are, to recognize that one company can't do everything, whether geographically or in product lines, and begin to specialize in areas where their expertise is strongest. Also, as Jeffrey R. Back, senior consultant with C. H. Kline & Co., of Fairfield, N.J., argues, coatings suppliers may sell into 30 markets but there will be only three top suppliers and a host of me-too producers. If all these come to pass, then surely the day is coming when there will be a world-class paint company. There are world-class symphony orchestras, world-class marathon runners, world-class skiers. Why not a world-class paint company? □

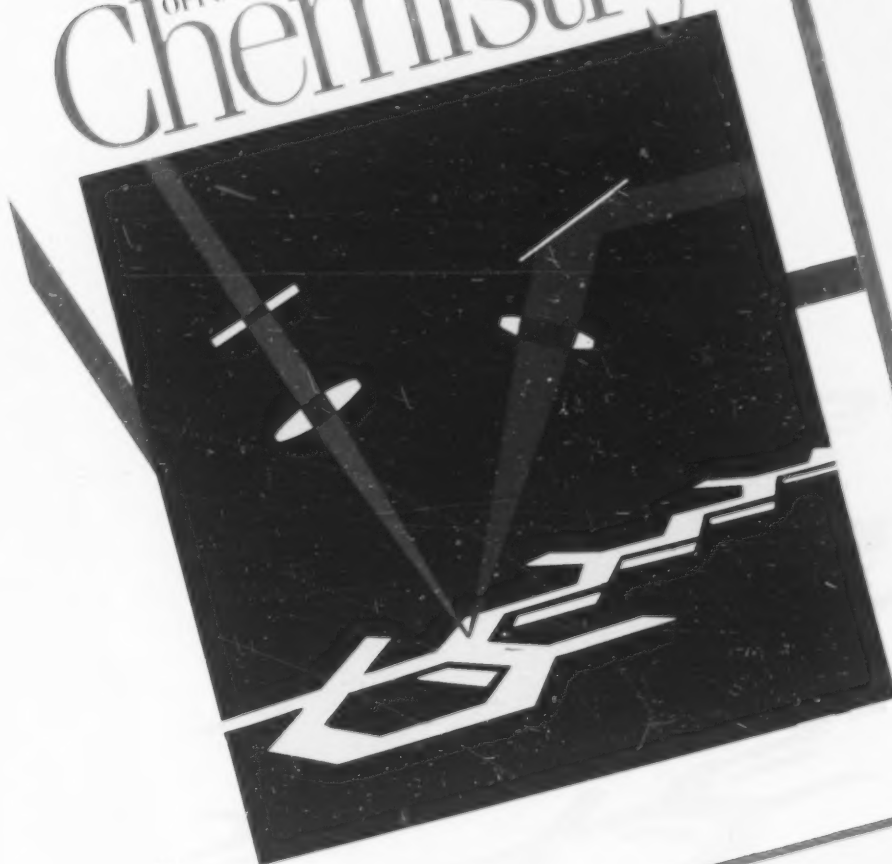


Water cooler shells emerge from electrodeposition tank at Ebco Manufacturing

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NEWS

OPPORTUNITIES IN
Chemistry



Long-awaited
Pimentel Report is issued
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News of the Week

■ Congressional case study charges Office of Management & Budget of abusing power by interfering in EPA's proposed asbestos ban. **Page 6**

■ Classification of carcinogens to be made more uniform with criteria prepared by international industrial panel. **Page 6**

■ Research center on planetwide environmental problems gets a home on Venetian island. **Page 7**

■ Statistics on accidents related to toxic chemicals, compiled for EPA, to be used in preparation of acute hazards list. **Page 7**

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Major U.S. chemical trade associations readying for new round of multilateral trade negotiations. **Page 26**

Government

Congress works on Superfund reauthorization and trade protection bills, appropriations for federal agencies. **Page 36**

Science

Bitter debate persists over possible cyanide presence in gas cloud at Carbide's Bhopal disaster. **Page 42**

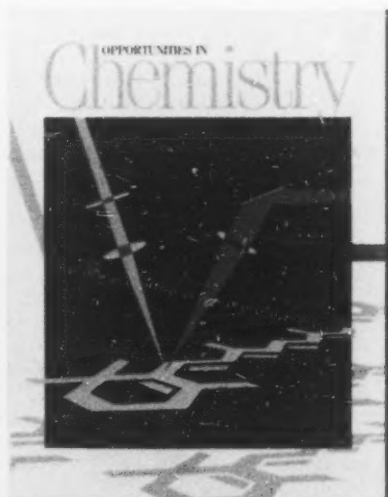
Technology

Newly developed polymeric material proving effective as nonstick coating that reduces drag at solid-fluid interfaces. **Page 44**

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ACS awardees: Danishefsky, Dessy, Gaspar, Giddings, Grasselli, Hansch, Hazen, Heathcock, and Hercules. **Page 46**

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News Focus

Pimentel Report draws consensus from the chemical community on the status of chemistry in general and the areas in chemistry that are ripe for experimentation. **Page 9**

Chemical Industry Hones Policy For Upcoming Trade Negotiations

Focal point of emerging policy continues to be multilateral trade talks, particularly the possibility of further cuts in tariffs

Earl V. Anderson, C&EN New York

It now appears certain that U.S. trade officials will be cramming for a new round of multilateral trade negotiations scheduled to be held next year under the General Agreement on Tariffs & Trade (C&EN, Oct. 7, page 12).

It also appears certain that the close-knit cadre of trade experts that mold chemical industry trade policy will find their schedules busier than ever. In the major trade associations, such as the Chemical Manufacturers Association and the Synthetic Organic Chemical Manufacturers Association, members of the international trade committees are

busy formulating a trade policy for their respective boards to approve.

Approved trade policy statements probably won't be long in coming. The industry's trade experts haven't been sitting on their hands waiting for GATT delegates to make their move in Geneva. Out of their preparatory work, one thing comes through loud and clear. The focal point of an emerging chemical industry trade policy is—and has been—multilateral trade negotiations, particularly the distinct possibility of further cuts in chemical tariffs.

That doesn't mean that the chemical industry has no other concerns about international trade. In various degrees and in various ways, U.S. chemical companies are concerned about many pieces of protectionist trade legislation now floating around Congress. But the industry's major trade spokesmen have been noticeably quiet about them.

One explanation is that industry liaison with Congress has been con-

centrated on what's considered to be much more important legislation, such as Superfund and tax reform. Industry personnel familiar with Congressional infighting are spread too thin to cover each of the many trade bills on Capitol Hill. Besides, says one industry expert, "there's a feeling that, in talking to Congress [on trade legislation], the chemical industry wouldn't be much of a factor" in influencing the outcome.

What the industry trade policy makers hope to influence, however, is the way U.S. trade negotiators approach the next round of multilateral trade talks. In all likelihood, the industry will endorse such talks even though there are many in the industry who feel that "we really don't need them, thank you."

The trick will be to come up with a policy that supports multilateral trade talks—but ones that will help rather than hurt U.S. chemical industry trade prospects. That's why possible tariff cuts loom so large in policy-making deliberations.

U.S. chemical industry stacks up in world trade this way

\$ Millions	1984 U.S. chemical trade		
	Exports	Imports	Trade balance
INDUSTRIALIZED NATIONS			
Western Europe	\$ 6,497	\$ 6,392	\$ 105
EEC total	5,467	5,578	-111
Belgium-Luxembourg	1,307	237	1070
Netherlands	1,072	526	546
West Germany	1,058	1,576	-518
U.K.	906	1,294	-388
France	566	1,172	-606
Italy	382	425	-43
Denmark	19	130	-111
Switzerland	328	387	-59
Japan	2,961	1,312	1649
Canada	2,752	3,131	-379
Australia	686	145	541
China	644	157	487
New Zealand	148	106	42
Eastern Europe	275	325	-50
U.S.S.R.	208	208	0

neg = negligible. Source: Bureau of the Census

\$ Millions	1984 U.S. chemical trade		
	Exports	Imports	Trade balance
DEVELOPING NATIONS			
Latin America	\$ 3,827	\$ 1,208	\$2619
Mexico	1,250	607	643
Venezuela	540	32	508
Brazil	526	414	112
Argentina	245	81	164
Asia	3,292	377	2915
Taiwan	723	200	523
South Korea	643	79	564
India	420	26	394
Singapore	296	16	280
Indonesia	231	16	215
Philippines	195	16	179
Malaysia	161	10	151
Thailand	154	2	152
Africa	510	196	314
Middle East	429	124	305
Saudi Arabia	240	neg	240
WORLD TOTAL	\$22,336	\$13,697	\$8639

Because the chemical industry is not so homogeneous as other industries such as steel or telecommunications, it's no surprise that opinions about future tariff-cutting exercises vary within the industry. One veteran industry trade official explains that "it's not like the good old days, when the entire industry could rally around ASP [American selling price]."

Today, many of those same companies that once looked upon imports as a problem are importers themselves. They are now part of the problem, says one company trade expert.

Despite this new twist to the industry's attitude toward tariff cuts, there's still a hard core of opinion that says giving the Administration "blank check" tariff-cutting authority on chemicals would do more harm than good. As evidence, they point to the industry's trade fortunes in the years since the massive tariff-cutting exercises of the Kennedy round of trade negotiations in the 1960s and the Tokyo round, which ended in 1979.

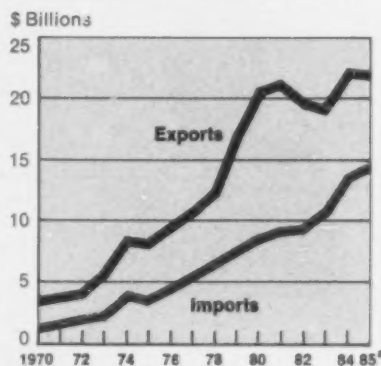
Exhibit A is the U.S. chemical industry's balance of trade. Trade has long been an important part of the industry's business, and it has chalked up an impressive record of successive trade surpluses. That surplus hit a high of \$12.1 billion in 1980, but has been sliding steadily ever since. Last year, the chemical trade surplus dropped to \$8.6 billion, and it could slip to about \$7.4 billion this year. That's almost a 40% loss in five years.

The big question for many is: Will further chemical tariff cuts really help? In past GATT trade talks, U.S. chemical tariffs were cut, on average, about 50% during the Kennedy round, then about 33% during the Tokyo round. Other industrialized nations, but not developing nations, also cut their chemical tariff rates.

However, over the past 15 years, U.S. chemical exports have not grown so fast as imports. In particular, between 1980 and 1985, U.S. chemical exports will have increased only 1% or so per year. Imports, on the other hand, have had a healthy 11%-per-year average growth rate.

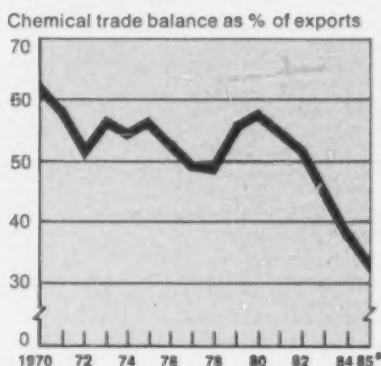
Equally disturbing is that U.S. exports to industrialized nations have

U.S. chemical imports grow faster than exports...



* C&EN estimate. Source: Bureau of the Census

... and surplus-to-export ratio shrinks



not grown so fast as those to developing countries. Yet it was the industrialized nations that cut chemical tariffs in previous GATT rounds; the developing world did not. For instance, between 1975 and 1984, U.S. chemical exports to developed

countries advanced at a nearly 12%-per-year clip. Exports to developing countries grew at a 14% annual rate, even though those exports actually declined between 1980 and 1984 because of debt problems in developing countries.

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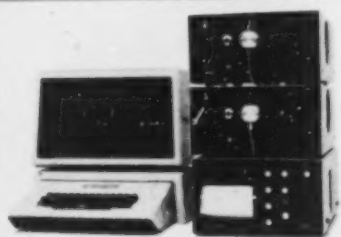
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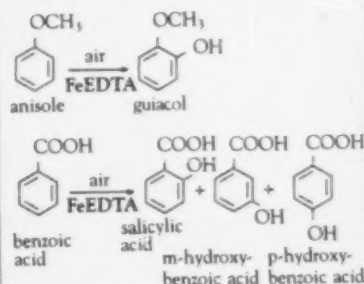
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Business

Despite such concerns, the chemical industry is not likely to come out foursquare against chemical tariff cuts in the upcoming trade negotiations. "We won't take a Neanderthal position and say 'no cuts,'" says SOCMA assistant director Stephen J. Kasprzak. Instead, the industry probably will support chemical tariff cuts, provided some major problems are taken care of first.

Some in the chemical industry feel strongly that GATT terms should be fixed first. International trading rules, dispute settlement procedures, and safeguards under GATT need repair, they say. As a result, many nations no longer believe that GATT can solve world trade problems, and they have gone outside GATT to negotiate solutions.

Another major headache is foreign government intervention in the free flow of chemical trade. Some governments restrict imports, prohibit or limit foreign investment, or add local purchase and export performance requirements when foreign investment is allowed. Others control access to raw materials for the benefit of domestic producers, target export markets, and have other policies that "impair the effectiveness of an otherwise competitive U.S. chemical industry."

Chemical industry support of tariff cuts, then, could be conditioned upon solving these unfair trade practices and governmental nonmarket behavior. But there are those who feel that terms such as "fixing the GATT" are cute phrases with little substance. It's naive, says one, to think that the U.S. will condition its participation in upcoming trade negotiations on fixing the GATT first.

Despite these different attitudes, trade policy statements will be essentially similar when they emerge from their various committees. "There's no doubt that we will reach a consensus on the major issues," says Allan J. Spilner, manager of trade issues for Rohm & Haas, and chairman of CMA's international trade committee. To be effective, however, he thinks that the industry will have to limit the number of points upon which it takes a position. "The key," says Spilner, "is to help the industry remain competitive."

OCTOBER 21, 1985

CHEMICAL & ENGINEERING

NEWS

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TERRORISM

**How vulnerable are
chemical plants?**
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■ Nobel prizes in chemistry and medicine honor U.S. research work in crystallography and cholesterol metabolism **Page 4**

■ Monsanto offers early retirement incentives to more than 10% of its salaried U.S. workforce. **Page 5**

■ EPA proposes concentration rules for eight volatile organic chemicals in drinking water. **Page 6**

■ Record high in particle reaction energies reached in Fermilab's first proton-antiproton collisions in its new facilities. **Page 6**

Business

Producers hope enactment of proposed trade bill will curb decline in U.S. output of polyester, nylon, and acrylic fibers. **Page 15**

Government

Department of Transportation issues tougher safety standards for vehicles carrying poisonous volatile liquids. **Page 20**

Technology

Two new processes for phosphoric acid production offer prospects for significantly reduced manufacturing costs. **Page 23**

Package system for recovery of poly (ethylene terephthalate) from plastic bottles touted in Western Europe. **Page 25**

Contract proposals for synthesis of inorganic/organic compounds sought by National Cancer Institute. **Page 27**

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"Controlling the Atom" by George T. Mazuzan and J. Samuel Walker gets to the roots of nuclear regulation. **Page 28**

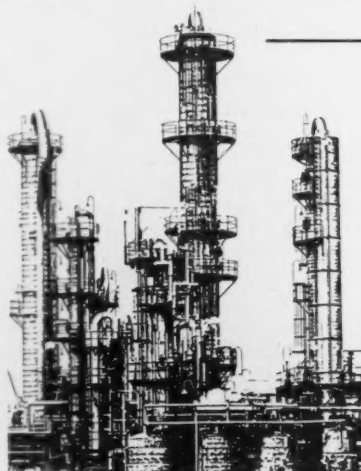
ACS News

Official reports from Chicago meeting reflect committee activism and concern on many matters. **Page 33**

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ACS award winners: Kenaga, Lee, Lewis, Marzocchi, Montgomery, Morawetz, Novotny, Patrusky, and Perkins. **Page 39**

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News Focus

Chemical and oil industries have not been exempt from terrorist attacks; expert on terrorism and security affairs Neil Livingstone offers advice on corporate security. **Page 7**

Hurting Synthetic Fiber Producers Look for New Curbs on Imports

Enactment of proposed textile trade bill to reduce imports of apparel could stem decline in U.S. output of polyester, nylon, and acrylic fibers

Bruce F. Greek, C&EN Houston

New legislation soon could curb the rising tide of imported apparel and other textile products, which continues to dampen U.S. production of polyester, nylon, and acrylic fibers. The proposed textile trade bill aims to reduce the rapid growth in apparel imports from several Asian countries. Whether this bill or other restrictions will succeed in restoring growth to U.S. synthetic fiber production remains to be seen.

Early in October, the bill was passed by the House and is now awaiting action by the Senate. Enactment of the bill, which might include passage over a Presidential veto, would further limit imports

from such countries as China, Hong Kong, Japan, South Korea, and Taiwan. In its present form, the bill would not limit imports from Canada or various West European countries.

Even if the textile trade bill becomes law soon, its effects will be a while coming. Thus the impact on 1986 production of acrylic, nylon, and polyester fibers could be rather

Key Polymers

small. Output next year could be above 1985 production, which is expected to total some 6.3 billion lb, accounting for most of the noncellulosic synthetic fiber production in the U.S. This production will be down about 3% from 1984.

Forecasts for production of these fibers in 1986 are tempered by two factors: potential restriction of imports by the textile trade bill and general economic conditions during the year. If, for example, a sig-

nificant recession begins in 1986, then fiber production would be affected more by the economic downturn than by lower imports. Although no growth in imports of apparel, or even a small decline in such imports, would ease the effect of any recession that might occur, fiber production still could slip, according to one industry observer.

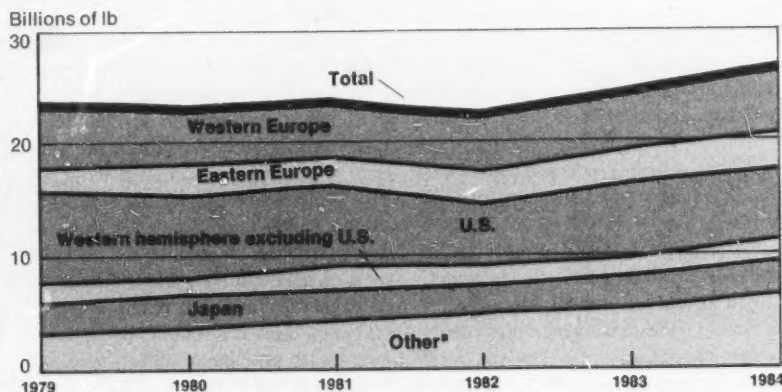
If imports of apparel and other textile products grow slowly after 1985, fiber production then would be influenced by growth in demand for the products. Although fashion can have an impressive impact on fiber demand, the total volume is so large that fashion doesn't really change production much in a year's time. Therefore, growth in fiber production for the rest of the 1980s likely will depend on population and economic growth. Generally, production will grow 2% or so annually, if imports are limited to the 1% a year annual gain called for in the proposed legislation.

If growth resumes for major volume synthetic fibers at a rate double population growth, production of individual fibers will not top historical volumes until 1990 or later. Even then, in spite of help from new fiber developments, total production might not exceed the 1979 levels.

Textile imports likely will be restricted, but not enough to halt the decline in demand for fibers. Competitive pressures will remain strong, making profitability marginal for many producers. A reduction in capacity to make apparel fibers would result, especially as equipment and processes become technically obsolete.

For details of the current year's outlook for the three major synthetic fibers, please see the following pages.

Eastern hemisphere countries account for most growth in synthetic fibers production

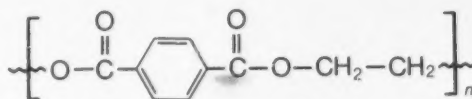


Note: Production excludes olefin fibers. * Africa, Asia, and Oceania. Source: Textile Economics Bureau

Key Polymers

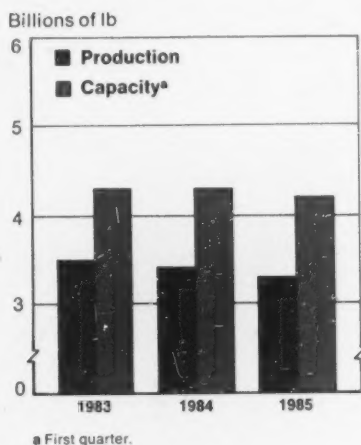
Polyester

- **Demand slipping**
- **Capacity easing**
- **Prices holding**



Poly(ethylene terephthalate)

PRODUCTION/CAPACITY



MAJOR PRODUCERS

Allied, American Hoechst, Celanese, Du Pont, Eastman

HOW MADE

Reaction of dimethyl terephthalate or terephthalic acid with ethylene glycol to make bis (2-hydroxyethyl)-terephthalate, which is polymerized catalytically to poly (ethylene terephthalate)

MAJOR END USES (U.S.)

Apparel 50%, home furnishings 20%, industrial 30%

FOREIGN TRADE

Exports—may total 400 million lb in 1985, imports—to remain less than 75 million lb

PRICES

Round 150-denier yarn about 90 cents per lb; staple about 80 cents per lb

U.S. producers of polyester fibers are meeting with moderate success in coping with the fast-rising tide of imported apparel. They are just keeping production from falling rapidly. For the near-term future, the effects of the textile trade bill, if enacted, will not be felt until next year.

For 1985, fourth-quarter demand for fibers is well set, and another small decline in polyester production seems to be almost certain. For this year, output will total about 3.3 billion lb, down 2.7% from 1984, making it the second year for a slight decline. The 1983 total was 3.55 billion lb, a year of strong recovery following 3.17 billion lb in the recession year of 1982, the lowest yearly production since 1975.

Capacity to make polyester fibers has been holding at about 4.3 billion lb a year. Thus, the average plant operating rate also is falling slowly. This year, for example, that rate will be 76.7%, if 3.3 billion lb of polyester fibers are made.

However, plant capacity to make polyester fibers depends on the size (denier) of the fibers produced. Generally, if a producer makes finer fibers (lower denier), its capacity in terms of weight declines. (Fiber denier is defined as the weight in grams of 9000 meters of filament or yarn.) Shifts in fashion demands for fabrics made partly or wholly of polyester fibers have caused a trend toward lower denier fibers. The mix of fiber products from plants also influences the plant capacity. Estimates of plant capacity for producing textile fibers could be high because of the shift to finer deniers alone.

A few capacity additions at plants making staple and yarn, and making large denier fibers for industrial uses such as tire cord, are offsetting the shift toward finer denier textile fibers. These additions of fiber capacity for industrial uses, however, are at plants where capacities are relatively small when compared with plants that make

textile fibers. These additions probably will be so small overall that total capacity will be up only 1 to 2% as 1986 begins, hardly more than the net effect of debottlenecking programs.

If textile trade legislation is passed and is unsuccessful in reducing the growth of imports of apparel made of synthetic fibers, it could cause future reductions in capacity. If imported apparel takes more of the market share away from apparel made domestically with polyester fiber, then operating rates for plants will decline further and capacity will be shut down.

This year U.S. consumption of polyester fibers will be down between 3 and 5%. Increased exports will help to keep production up, but some inventory reduction will offset those exports. Almost all of the decline in demand will occur in apparel uses, which account for about half of U.S. consumption.

Major changes in fashion also have affected consumption of polyester fibers. The slide in demand for 100% polyester fabrics appears to have ended, but at the cost of about a 60% loss in this market. Greater use of blends with wool and cotton to give garments a texture closer to that of all-natural fiber fabrics has cut into use of 100% polyester fabrics.

Other uses of polyester fibers—industrial and home furnishings including automotive upholstery—are, at worst, about level in demand. Most are up slightly.

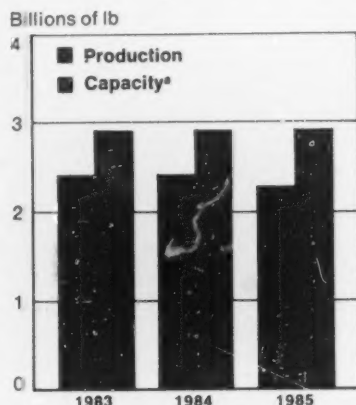
Polyester-cotton blends have shifted to a 65-35 ratio from 50-50 for bed linens, aiding demand. Cloth interiors of mostly polyester for new automobiles now account for about 90% of auto production, in contrast to about 90% vinyl a few years ago. Tire cord, as the single largest industrial use of polyester fiber, accounts for about a third of consumption. Nonwoven uses of polyester staple, at about 100 million lb in 1984, are a continually growing market and are another important part of this use category.

Key Polymers

Nylon

- **Demand down**
- **Capacity steady**
- **Prices holding**

PRODUCTION/CAPACITY



a First quarter.

MAJOR PRODUCERS

Allied, Badische, Du Pont, Monsanto

HOW MADE

Nylon 66—adipic acid and hexamethylene diamine reacted to form hexamethylene diammonium adipate, which is polymerized by removal of water; nylon 6—caprolactam and water reacted to form aminocaproic acid, which is polymerized by removal of water

MAJOR END USES (U.S.)

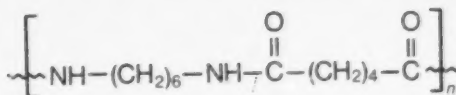
Home furnishings 60%, apparel 20%, industrial 20%

FOREIGN TRADE

Exports—to hold at about 125 million lb in 1985, imports—remaining under 100 million lb

PRICES

Carpet staple \$1.10 to \$1.25 per lb; low-denier textile fiber \$2.00 per lb



Nylon 66

Production of nylon fibers and filaments is expected to slip slightly in 1985, similar to the production declines of other major synthetic fibers. Reasons include some impact from apparel imports, minor reductions of retail apparel inventories, and weaker industrial demand.

Production of nylon fibers in 1985 will total almost 2.3 billion lb, down about 4% from 1984. Production had held at very close to 2.4 billion lb for two years, following the recovery from the recession low of 1.9 billion lb in 1982 (the record high of more than 2.7 billion lb occurred in 1979).

Capacity to make nylon fibers is holding at an annual rate of about 2.9 billion lb, or perhaps a bit more. Changes in fiber size (denier) for nylon to a smaller denier have been minor. Consequently, the reduction in capacity measured as weight of fibers produced is small. Debottlenecking and process efficiency improvements are likely to increase capacity slightly, perhaps 1% or so.

Production in 1985 will amount to 2.3 billion lb, giving an annual operating rate of 79% of nameplate capacity. At this level, little reinvestment capital can be developed.

Both exports and imports have relatively little impact on nylon output and consumption. Exports, expected to be about 125 million lb and made up largely of industrial deniers, have remained in the 100 million to 150 million lb-a-year range for the 1980s. Imports, exclusive of waste fibers, could reach 75 million to 100 million lb this year.

Imports of apparel made with nylon fibers significantly affect consumption of nylon in the U.S., but not so much the demand for acrylic and polyester fibers. This is because apparel accounts for only about 20% of U.S. nylon consumption, well below levels of the other fibers.

Consumption of nylon fibers in apparel also has been hurt this year by efforts to reduce inventories of wom-

en's lingerie at the retail level. Fashion trends toward dresses and away from jeans and slacks continue to bolster the demand for nylon hosiery, but growth in this area is small.

The largest use of nylon fibers—home furnishings, at 60% of total consumption—is showing some growth because of the high level of housing construction. Most of the consumption is in carpets and rugs, which take a bit over 50% of all nylon fiber production. Lower mortgage interest rates are helping both new home sales and sales of used homes. Because new home sales stimulate used home sales (and very frequently carpeting is replaced just after the purchase), forecasts for continued relatively low interest rates bode well for nylon carpet fiber sales.

Despite competition from polyester, polypropylene, acrylic, and other synthetic and natural fibers, nylon fibers have held onto more than 75% of the carpet market for most of the past 10 years. Polypropylene fibers appear to be the strongest competitor in the future because of demand in commercial carpet, but nylon probably will hold its share of the total market for quite some time.

Tire cord is the largest industrial use of nylon fiber. Nylon tire cord goes largely to farm tractor, bus and heavy duty truck, and industrial tires. None of these markets have shown much growth, and tractor and industrial construction nylon tire cord demand has declined recently, as finished tire inventories were reduced. Other industrial uses such as hose and belting reinforcement and cordage are on hold.

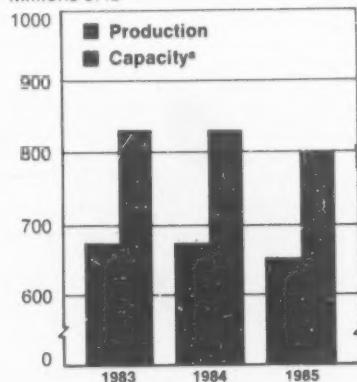
Even with some limitations on consumption because of imported finished textile products, the nylon fibers segment of the synthetic fibers industry keeps moving ahead slowly. Growth in demand will continue but not so fast that capacity expansions will be needed this decade. Nylon likely will retain its markets and may even slowly gain market share.

Acrylics

- Demand off a bit
- Capacity down
- Prices level

PRODUCTION/CAPACITY

Millions of lb



a First quarter.

MAJOR PRODUCERS

American Cyanamid, Badische, Du Pont, Monsanto

HOW MADE

Polymerization of acrylonitrile with small amounts of other acrylate comonomers

MAJOR END USES (U.S.)

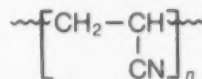
Apparel 65%, home furnishings 30%, industrial 5%

FOREIGN TRADE

Exports—expected to total 200 million lb in 1985, imports—to hold at about 25 million lb

PRICES

3-denier staple for apparel 90 cents to \$1.10 per lb



Polyacrylonitrile

Of the synthetic fibers, acrylics have the most problems. Demand declines as imported apparel takes markets from domestic apparel. Competition from acrylic fiber produced in other countries minimizes profitability from exports. And, unless capacity is reduced, plant operating rates will decline, further reducing overall profitability.

Imported apparel has been hurting U.S. acrylic fiber consumption longer and more seriously than it has other fibers, leading to more efforts by producers to develop specialty fibers for U.S. consumption. Despite these efforts, demand for acrylic fibers has trended downward during the 1980s.

Production of acrylic fibers in 1985 likely won't reach 650 million lb. But if it does, it still will be down about 3% from 1984. Production may be lower because the fourth-quarter production slump could be greater than usual.

After holding relatively steady for several years, capacity to make acrylic fibers declined last year to about 800 million lb. This is down substantially from the recent peak of 870 million lb during 1976, 1977, and 1978.

If production totals only 640 million lb in 1985, then the 800 million lb of plant capacity available as the year began will have an average operating rate of 80%. Because exports account for nearly a third of production and are sold at discount prices, profitability at this level of plant operation is meager.

Estimates by the Textile Economics Bureau for future acrylic fiber capacity indicate that it may decline this year and next. The decrease will result more from plant production unit shutdowns than from changes in fiber denier, which has been holding quite constant. The capacity decline may amount to 5 to 7% this year.

Exports of acrylic fibers will total about 200 million lb in 1985, down about 10% from 1984 exports. Exports are forecast by some industry sources to continue to slip, as this

often marginally profitable segment of the business is curtailed.

Domestic demand for acrylic fibers will be about the same as last year. The growth in imports of acrylic fiber sweaters apparently has leveled off, with these imports taking about two thirds of the sweater market. Part of U.S. acrylic producers' success in fighting imports stems from development of special variations in acrylic fibers for sweater knitters to make U.S.-produced sweaters that are noticeably different from imports. If legislation is passed to restrict apparel imports, then demand for acrylic sweaters very likely will benefit.

Socks made from acrylic fibers also are facing difficult times from imports, but these imports also seem to have leveled off. Competition from cotton in socks waxes and wanes with cotton production and prices. Fashion and the emphasis on physical fitness, as it affects demand for athletic socks, are offsetting much of the cotton price effect on competition between these two fibers.

After a year or more in the doldrums, demand for acrylic fiber craft yarns picked up this year. However, this use of acrylic fibers likely does not have much longer-term demand growth, with annual consumption forecast to hover around 75 million lb a year.

Other apparel uses of acrylic fibers such as pile fabrics and fleeces (circular knits) are up and down. Fleeces, for both fashion and fitness reasons, continue to grow quite well by standards for commodity fibers. Pile fabrics are down a little in demand as a result of a shift to fiber-filled garments, often with polyester waste as the fill or insulation material.

Carpets, rugs, blankets, curtains, draperies, and other uses are in the home furnishings area of acrylic fibers. None of these uses are changing much and they face continued competition from polyester, nylon, cotton, and wool in the marketplace.

OCTOBER 28, 1985

CHEMICAL & ENGINEERING

NEWS



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BETHESDA MD 20814

1986 Employment Outlook

The transition from scientist to manager:
It takes more than ability and hard work
Page 27

News of the Week

■ First of five planned regional meetings kicks off discussions of Pimentel Report to brief chemical community on report's contents and catalyze support for it. **Page 6**

■ American Institute of Chemical Engineers Issues book on procedures for evaluating hazards in chemical plants. **Page 7**

■ U.S. chemical companies report continuation of earnings decline in third quarter. **Page 8**

■ Sale of genetically engineered growth hormone for treating pituitary disorder approved by FDA. **Page 9**

■ Bristol-Myers agrees to purchase Genetic Systems for more than \$240 million. **Page 9**

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Business

Biotechnology company Molecular Genetics finds selling products to farm market harder than expected. **Page 12**

Government

EPA's latest strategy for hazardous chemical air emissions control depends on state and local cooperation. **Page 16**

Binary chemical bomb still has technical problems, although the Defense Department has declared it ready for production. **Page 17**

Technology

Coal gasification plant that was part of ammonia-from-coal project will switch focus to production of fuel, other chemicals. **Page 21**

Completion of new science quadrangle at the University of Chicago marked by dedication of physics teaching center. **Page 22**

Awards

ACS award winners: Ruckenstein; Shakhshiri; Sinfelt; Stilling; Viola; Weisz; Whetten, Grant, and Ezra; and Wolynes. **Page 54**



Employment Outlook

C&EN's annual look at the job picture gives some advice to scientists and engineers who are striving to move into management positions. **Page 27**



1986 Employment Outlook

Career Opportunities for Chemical Professionals

Despite predictions a year ago that demand for chemists and chemical engineers would rise in 1985, many employers actually are hiring fewer chemical professionals this year. The job market is being depressed as companies attempt to combat declining profits by cutting costs and running leaner operations. A rash of mergers in the past year or two also has restricted new hiring.

The overall result is a decidedly spotty look to the current employment picture. The situation certainly is improved from what it was two or three years ago, especially for chemical engineers, but it is still considerably weaker than it was during much of the 1970s.

On several university campuses, employers were recruiting this year's graduates a bit more briskly than was the case last year. On the other hand, employment advertising in C&EN this year is running slightly below last year's level, and employment activity at last month's ACS national meeting was slower than the year before.

Career Advancement

Scientists and engineers who want to become managers must carefully plan their strategy for reaching their goals. Good job performance alone, although important, is not enough.

Page 28

Demand

The employment picture for chemists this year did not live up to expectations. Some observers also fear that the demand for such professionals will not improve significantly in 1986.

Page 40

Salaries

Median salaries of chemists and chemical engineers grew this year. Between 1984 and 1985, they rose 6% for inexperienced B.S. chemists, 4% for their experienced counterparts.

Page 45

Career Planning

The American Chemical Society and other organizations can furnish a variety of useful information to people seeking advice about careers in chemistry and chemical engineering.

Page 47



Cuts in hiring by many employers dampen job prospects for chemists and chemical engineers

Demand

The job market for chemists and chemical engineers has been distinctly spotty this year. Although demand for chemical professionals clearly is stronger in 1985 than it was two or three years ago, the situation compared with last year is pretty much a standoff. On many university campuses, company recruiters were more active in the past 12 months, so that new graduates, especially chemical engineers, have found it easier to land jobs than was the case in 1984. On the other hand, many major employers of chemists and chemical engineers have cut back their hiring appreciably.

In any event, demand for new chemists and chemical engineers did not expand this year as many

college placement people and company recruiters had expected it would a year ago, when C&EN last took a look at the employment outlook for chemical professionals. As one university professor laments, "Although the employment situation this year is relatively good, it certainly isn't as excellent as it was 10 years ago."

Job prospects this past year for recently graduated chemists and engineers were similar to those for other recent graduates. As the College Placement Council puts it, "The 1984-85 college recruiting season began with optimistic projections. With the economy gaining momentum, the job outlook for new college graduates seemed excellent. But the year was full of surprises." The council adds that 1984-85 was "a good recruiting year, but one that fell short of expectations."

Other indicators of the job picture

for chemical professionals are a similar mixed bag. The unemployment rate for chemists dropped to 1.4% last March, down from 1.7% a year earlier and 2.2% in March 1983, according to the American Chemical Society's annual survey of its members. Joblessness among chemical engineers also is down this year, according to the American Institute of Chemical Engineers. But help-wanted advertising in C&EN has been trending moderately downward from its peak levels of about a year ago. And recruiting activity at the Employment Clearing House during the ACS national meeting this past fall was less robust than at the national meeting a year earlier.

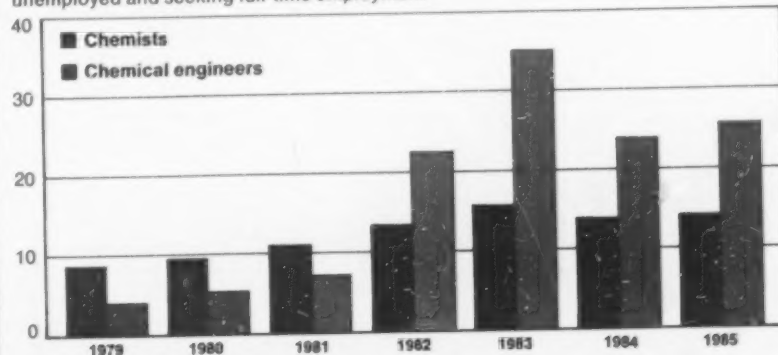
Mixed results are reported for recruiting at college chemistry departments. All chemistry Ph.D.s at Purdue University, for example, had jobs when they finished the 1984-85 academic year, as was the case for the previous academic year. In both years, too, new Ph.D.s typically had one or two job offers. On the other hand, in the late 1970s, chemistry Ph.D.s usually had four or five offers from which to choose.

Chemistry graduates this year, says Robert E. Wild, chairman of graduate admissions and placement-service liaison for Purdue's chemistry department, had to be more aggressive than usual in seeking jobs because of widespread economic uncertainty among employers. As a result, they had to have more job interviews both on and off campus.

Wild indicates that all Purdue's M.S. chemistry graduates in 1984-85 also had positions when they graduated this year. However,

Unemployment is down from 1983 for newly graduated chemists and chemical engineers, but continues high

Percentage of new bachelor's degree recipients who were unemployed and seeking full-time employment



Note: Data as of the summer of each year. Source: ACS starting salary surveys

only about 70 to 75% of the B.S. students who were looking for jobs had found them by graduation.

Audrey L. Aylesworth, chemistry placement coordinator at the University of Wisconsin, Madison, indicates that of the 35 Ph.D. candidates who interviewed for industrial positions in the 1984-85 school year, five reported no job offers as of mid-July. Industrial job offers averaged 2.6 per person (two students got six offers), compared with 3.1 offers in 1981-82, 1.5 in 1982-83, and 2.1 in 1983-84.

Twenty-four B.S. chemists graduating from the University of Wisconsin, Madison, in 1984-85 attempted to get industrial positions, but only seven were successful by the time they graduated. The average number of offers was 2.1 per person in 1984-85, compared with 2.3 in 1983-84. In the 1983-84 academic year, 11 of 23 B.S. graduates who were looking for industrial jobs succeeded in finding them.

At the University of Illinois, Urbana's school of chemical sciences, the number of employers who interviewed graduating students rose 11% in 1984-85, although the number of days they spent on campus decreased slightly. Rebecca J. Simon, the school's placement director, says that job offers received by graduating B.S. chemists in 1984-85 were 12% fewer than in 1983-84; job offers made to graduating Ph.D. chemists declined 24%.

Ph.D. chemistry graduates at the University of Minnesota in 1984-85 received on the average about two job offers, and by July only one student was without a position. Chemistry professor Paul G. Gassman also notes, "This past spring, several companies asked us to recommend B.S. people for employment, but by that time all of our B.S.s either had jobs or were going on to graduate school."

Chemistry graduates at Duke University this year likewise had relatively little difficulty finding jobs. Ph.D. graduates, says Charles H. Lochmüller, chairman of Duke's chemistry department, received from two to five offers. Of 50 B.S. or B.A. graduates in chemistry, 40 went on to graduate studies in chemistry or business administra-

tion or to medical or law school and those seeking chemical jobs got them "fairly readily," he says.

A similar report comes from the University of Oklahoma's chemistry department. Stanley C. Neely, assistant chairman of the department, says that all of its 1984-85 B.S., M.S., and Ph.D. graduates who were looking for an industrial or academic position had one at graduation time. He believes that graduates found it easier to get jobs in part because more companies outside the Southwest and not in the petroleum industry sent recruiters to the school in the past academic year.

Employment prospects for chemistry graduates of some schools have been affected adversely by depressed economic conditions locally. At the University of Houston, where many chemistry graduates in the past have taken jobs in the petroleum industry, chemistry students have faced tough sledding in finding jobs.

Mamie W. Moy, associate chairman of Houston's chemistry department, says that only about a fourth of its 1984-85 chemistry graduates (at all degree levels) had jobs in chemistry when they graduated. Since then, another 50% or so have obtained employment. Although the recent picture was far from rosy, it was better than in 1983-84, when the petroleum industry, Moy says, "hit rock bottom in hiring chemists and chemical engineers."

She points out that, in the mid-

1970s, essentially all of the university's chemistry students had jobs when they left school. She also indicates that although she encourages students to look for employment where jobs would be more plentiful outside the Southwest, she finds that many of them, especially the B.S.s, are reluctant to move to other parts of the country.

For chemical engineering graduates, the recent job picture has not been good, but is getting better. It was very bad in 1982-83, when demand for engineers decreased sharply at a time when they were graduating in unprecedented numbers.

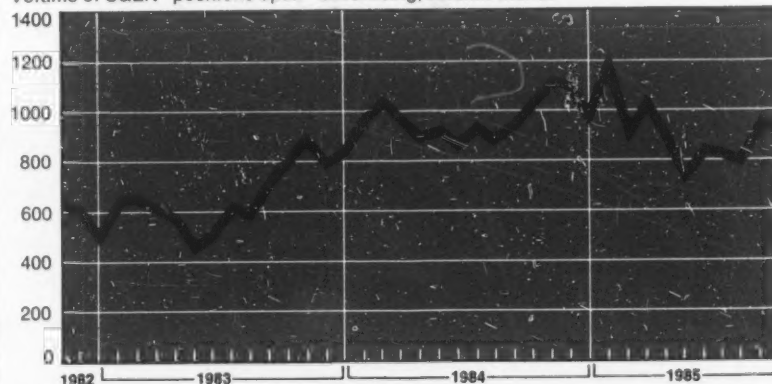
William L. Conger, head of the chemical engineering department of Virginia Polytechnic Institute & State University, says that about 70% of its B.S. chemical engineering graduates who were looking for jobs this year had them at graduation time, up from 50% in 1983-84 and only 30% in 1982-83. Ten years ago, practically all chemical engineering graduates had jobs when they left school.

Conger points out that about 25 B.S. chemical engineers in the class of 1985 were still searching for employment when they graduated. By September, only about 10 were without jobs.

The job market for new chemical engineers, he believes, likely will improve in the years immediately ahead. One reason is that the number of new graduates will decline,

Help-wanted ads have slipped from 1984 level

Volume of C&EN "positions open" advertising, column-inches*



* Column-inches published during consecutive periods of four weeks each; no issues were published in the last week of December 1982, 1983, and 1984.

Hiring of chemists slowed by business conditions

Job prospects for chemical professionals worsened this year and are expected to deteriorate still further next year, a C&EN survey of employers of chemists and chemical engineers indicates. Employers are hiring fewer chemical professionals in 1985 than they did in 1984. And the decline is expected to continue into 1986, although it is likely to be less marked then.

Business conditions get much of the blame. About a third of the organizations surveyed indicate that hiring has been greatly influenced by prevailing stagnant sales and low earnings. Another third say that current business has had at least a moderate impact on hiring.

As one company personnel official puts it, "The current economic picture has caused us to curtail or halt our plans to expand our research efforts, and this, in turn, has reduced our need for new chemists. We are mainly hiring to replace people who are promoted and have left the company." Another notes, "The significant decrease in our profits in the first quarter of 1985 has greatly reduced our technical recruiting."

The remaining third of the survey respondents claim, however, that economic factors have had little or no effect in the past 12 months on their hiring of chemists. One points out, "Our hiring for research is insulated, to a considerable

extent, from economic fluctuations." This point is seconded by another company: "Our hiring reflects the status of our research efforts, which are more influenced by the strategic direction of our company than by the business climate."

Results from this year's survey are based on responses from 36 organizations, most of them chemical companies. A few responses came from research institutions.

These organizations employed about 18,900 chemists and 20,600 chemical engineers as of mid-1985, numbers that are essentially unchanged from 12 months earlier. Little further change is expected in these totals by mid-1986, moreover. Women account for 14% of

lessening competition for jobs. The size of the sophomore class in chemical engineering at Virginia Tech has dropped from about 90 in the fall of 1983 to 42 in the fall of 1985. This decrease reflects the belief of many students that chemical engineers have a tough time getting jobs, a perception far more true in 1983 than in 1985 and maybe not true at all in 1988.

The University of Illinois, Urbana, likewise reports that the job market for chemical engineering graduates is improving, with 8% more job offers made to graduating B.S. chemical engineers in 1984-85 than in 1983-84. Offers to Ph.D. chemical engineers increased 28%.

At State University of New York, Buffalo, the job market for new B.S. chemical engineers is still poor, although it is improving. Thomas W. Weber, chairman of SUNY Buffalo's chemical engineering department, says that 32% of new B.S. graduates had jobs when they left school this year, up from 21% for the class of 1984. The percentage of graduates who were still looking for jobs at graduation time rose slightly, however, whereas the percentage of those who planned to do graduate work fell from 21% to 5%.

"The job market was so bad for the class of 1984 that an unusually large number of our new B.S. graduates decided to do graduate work," Weber comments. "On the other hand, B.S.s in the class of 1985 appear to have been much more optimistic

about their prospects of finding jobs after graduation."

The 59 B.S. chemical engineering students who graduated from the University of Washington in June 1985 had an easier time finding employment than did the 72 B.S. chemical engineers who graduated a year before. Charles A. Sleicher, chairman of the chemical engineering department, reports that 63% of 1985 graduates had jobs by September, compared with 50% of the June 1984 graduates. As for Washington's M.S. and Ph.D. chemical engineers, all who graduated in June 1985 had jobs when they left school.

Some university people emphasize that the 1984-85 job market for newly graduated chemists was not so good as had been anticipated a year ago, partly because the unexpectedly large decline in profits in the first half of this year led many employers to reduce hiring.

In the face of declining income and a desire to run a leaner operation, for example, Du Pont in academic year 1984-85 hired only about 50 chemists, primarily Ph.D.s. Du Pont had hired about 200 chemists in 1983-84. Du Pont emphasizes that it has reduced its hiring of all types of scientists and engineers—not merely chemists.

Donald L. Dinsel, manager of specialty staffing at Du Pont, stresses that, despite the company's cutback in the hiring of chemists and other professionals, Du Pont still has a strong commitment to research and

development. "Hence, we have an obvious need for chemists," he says. "And just because we are making a heavy investment in the life sciences does not mean that we are abandoning other R&D areas."

Monsanto's hiring of chemists last spring was significantly less than had been predicted in the fall of 1984, says technical employment manager Dale B. Fox. This change resulted from a variety of factors, including the slowdown in the company's business in early 1985. In addition, Monsanto is installing a new \$150 million research center for work on biotechnology and related fields—an effort that is requiring the increased hiring of molecular biologists, cell biologists, microbiologists, plant scientists, and others in the life sciences. Although biotechnology research also needs chemists, the company is tending to transfer into this area chemists now on its staff, rather than hire new ones.

Fox also points out that the company's need to employ new chemists has diminished as a result of its efforts in 1985 to de-emphasize its less profitable product lines. He adds that predicting how many chemists the company may require in the future has become more complicated because of its recent acquisition of G. D. Searle & Co.

Union Carbide's financial problems this year also have lessened its hiring of chemists. In August, the company announced that to reduce

the chemists and 9% of the chemical engineers, levels which also are not expected to change by mid-1986.

Although a year ago employers were saying that they intended to increase their hiring of chemists and chemical engineers moderately in 1985, now they expect that hiring will be down this year from 1984 close to 40% for chemists and nearly 30% for chemical engineers. And a further drop is seen next year—almost 20% for chemists and 15% for chemical engineers.

Slightly more than half the chemists hired this year and last were new graduates, but employers currently expect about two thirds of those offered jobs next year will be inexperienced. About

three fourths of the chemical engineers expected to be hired this year and in 1986 will be new graduates, about the same as in 1984. Nevertheless, one employer points out that since "recent mergers in the chemical industry have led to an abundant supply of experienced, job-seeking chemical professionals, we now are more likely to recruit these people than new graduates."

Employers indicate that they made 6% more visits to college campuses to recruit both chemists and chemical engineers during the 1984-85 academic year than they had the year before. During the current academic year, however, they plan to cut back such recruiting about 10% or so.

Most organizations add that they are looking for chemists with specialized skills this year, with the most frequently mentioned specialists being (in decreasing order) organic chemists, analytical chemists, polymer chemists, physical chemists, and biochemists.

Despite their current reduced interest in hiring, 80% of the respondents think that the employment outlook for chemists in their organizations will range from good to very good for chemists during the next five years; for chemical engineers, more than 70% think the outlook is good or better. Although no one indicates that job prospects will be poor for chemical professionals, no one describes them as excellent, either.

costs, it would decrease its salaried staff by 4000 by early next year. This 15% reduction will be brought about mainly by offering employees incentives to take early retirement.

To date, Carbide has given no indication of how many of these 4000 people will be chemists, although a significant number are expected to be. Carbide's plans to shut down some chemical plants and sell others also will diminish the size of its chemical staff.

Another company whose financial difficulties have reduced its demand for chemists is Hoffmann-LaRoche. In February, the company stated that it had dismissed about 1000 employees nationwide, most of whom were in New Jersey, where the firm has its headquarters and most of its research facilities. (According to some noncompany reports, the figure was at least 1400 employees.) Hoffmann-LaRoche declines to indicate how many of those terminated were chemical professionals. However, the ACS Committee on Professional Relations has indicated that at least 122 were chemists or chemical engineers.

Other companies have forced significant numbers of experienced chemists and chemical engineers onto the job market and thus increased competition for employment. For example, Chevron Corp.'s takeover of Gulf Corp. early this year led to the dismissal of a large number of Gulf's chemical profes-

sionals. Chevron abolished thousands of jobs of all types at Gulf to increase "efficiency through the elimination of overlap."

Exxon Research & Engineering Co., which employs most of Exxon Corp.'s scientists and engineers, says that, because of marked declines in the corporation's profits in recent years, it has found itself with a considerable surplus of employees. As a result, Exxon Research has not had an active campus recruiting program for scientists or engineers, for the past three years. However, within the past month or so, it has instituted a small on-campus recruiting program. "A healthy proportion of the new people we will be looking for," says an Exxon spokesman, "will be chemists and chemical engineers."

Not all chemical companies have cut back on hiring chemists, however. In the past two years, Rohm & Haas has hired about 100 Ph.D. chemists and other scientists. Normally, it would have hired only about 50 Ph.D. scientists in a two-year period. The main cause of this growth, says placement supervisor James D. Burke, has been expanding research on pesticides and specialty polymers.

Procter & Gamble reports that it hired more Ph.D. chemists and life scientists in 1985 than in any other year in its history. Ted J. Logan, manager of the company's Ph.D. recruiting, says, "Our growing research and development efforts, es-

pecially in the health-care and pharmaceutical areas, has increased our demand for life scientists but has not reduced our need for chemists."

Many university placement people expect job prospects for next year's chemical graduates to be about the same as they were for the class of 1985. But several observers emphasize the great difficulty in predicting the economy early next year—a factor that could greatly influence demand for graduates.

Simon of the University of Illinois expects that demand for chemistry graduates in 1985-86 will be "about the same as it was last year." She notes, "We have about the same number of employers scheduled now as we did last year at this time."

Fox of Monsanto believes that the demand for chemists in 1986 will be no stronger than in 1985 because of the decline in the profitability of commodity chemicals. Logan of Procter & Gamble expects demand for Ph.D. chemists in 1986 to be down about 20% from this year because of disappointing profits and sizable acquisitions by some major companies. Acquisitions often result in overlapping functions in the new company, leading to lost jobs and lower recruiting.

Burke of Rohm & Haas believes that companies will be placing more stress than ever on efficiency and reducing overstaffing. This trend will probably reduce the demand for chemists and chemical engineers. Burke says, "Our company's

goals for professional recruiting this coming year will be rather modest."

The prevailing view, however, is that graduating B.S. chemical engineers will find it easier to get industrial jobs in 1986 than did their counterparts in 1985, in part because fewer will be graduating.

Julian C. Smith, professor of chemical engineering at Cornell University, notes that the marked shrinkage in job openings for chemical engineering graduates in 1982 and 1983, with the resulting sharp dropoff in chemical engineering enrollments, has reduced the size of Cornell's graduating classes for 1986 and 1987. "In the next two years," he says, "we expect to grant no more than 30 to 35 B.S. degrees in chemical engineering, compared to almost 60 in 1985."

Conger of Virginia Tech expects that at least 80% of its B.S. chemical engineers in the class of 1986 will have jobs when they graduate, compared to 70% for the previous graduating class. He also says that several company recruiters already have indicated that they plan to hire more chemical engineers next year.

The College Placement Council reports that the new B.S. chemistry graduates received 12% fewer job offers as of July 1985 than as of July 1984. New Ph.D. chemistry graduates got 24% fewer offers. On the other hand, new B.S. chemical engineers received 8% more offers and Ph.D.s got 28% more.

The 169 reported offers made to B.S. chemists as of July 1985 were considerably fewer than the number

of offers to B.S. computer scientists (3796), mathematicians (565), or health professionals (288).

The council also indicates that as of July 1985, male B.S. chemists received 34% fewer offers than they did in the 12 months ending July 1984. Women B.S. chemists, on the other hand, got 25% more offers. Male B.S. chemical engineers received 14% more offers, but women B.S. chemical engineers got 3% fewer offers.

Despite gloomy reports from some employers about their recently decreased demand for chemical professionals, the 1.4% overall unemployment rate among ACS-member chemists on March 1, 1985, is lower than in any year during the past 15 except for the three-year period from 1979 to 1981. The latest annual ACS survey shows that the unemployment rate on March 1, 1985, was 2.0% for chemists with B.S. degrees, 1.6% for those with M.S. degrees, and 1.1% for Ph.D.s.

The American Institute of Chemical Engineers also finds that the overall unemployment rate among its members has declined in the past few years, to 2.8% last February. The rate was 4.3% in February 1983 and 3.2% in February 1984. The 4.3% figure for 1983 was the highest since the institute began surveying its members in 1971. Although pleased with the 1985 finding, AIChE says, "We had expected a greater decrease. It now seems that it may take a longer period of time to reach the heydays when the rate of unemployment was a low 1% or less."

The Employment Clearing House at the ACS national meeting in Philadelphia in August 1984 was described as "extremely busy," with the mood of both employers and job applicants "decidedly upbeat." At the most recent ACS clearinghouse during the national meeting in Chicago this past September, however, activity was down and the prevailing mood was less bullish.

Employer representatives totaled 240 at the Chicago clearinghouse, compared with 290 in Philadelphia. Job applicants dropped to 776, compared with 842 in Philadelphia, and the number of positions listed for candidates' review was 350 (vs. 446). The total number of job interviews was 1770 (vs. 2428), and the average number of interviews per candidate came to 2.3 (vs. 2.9). Employer representatives in Chicago, says one observer, were not only less active in seeking new people but were unusually specific about the types of positions they were attempting to fill. The types of chemical professionals that employers were looking for at the Chicago clearinghouse were primarily (in decreasing order) analytical chemists, organic chemists, polymer chemists, chemical engineers, and biochemists.

The volume of "position open" advertising in C&EN this year similarly indicates that demand for chemical professionals has been weakening. The number of column-inches of such advertising in the first 40 issues of 1985 was 9125, 4% less than in the first 40 issues of 1984. Actually, though, the 1984 level was unusually high, 53% greater than the amount of such C&EN advertising published in the first 40 issues of 1983.

Overall demand for scientists and engineers is reflected in the high-technology index published by Deutsch, Shea & Evans, a recruitment advertising agency, which bases its index on the volume of recruitment advertising directed to scientists and engineers. The index fell from 135 in July 1984 to 125 in December 1984. After rising slightly to 127 in February 1985, it has dropped since then to 105 last July. Even though the July figure was a two-year low, DS&E believes that further declines are likely. □

Chemistry grads increase at M.S. and Ph.D. levels; chem engineering grads higher at all levels

Academic year	Degrees awarded in chemistry ^a			Degrees awarded in chemical engineering		
	Bachelors	Masters	Ph.D.s	Bachelors	Masters	Ph.D.s
1973-74	10,525	2138	1828	3454	1045	400
1974-75	10,649	2006	1824	3142	990	346
1975-76	11,107	1796	1623	3203	1031	308
1976-77	11,322	1775	1571	3581	1086	291
1977-78	11,474	1892	1525	4615	1237	259
1978-79	11,643	1765	1518	5655	1149	304
1979-80	11,446	1733	1551	6383	1271	284
1980-81	11,347	1654	1622	6527	1267	300
1981-82	11,062	1751	1722	6740	1285	311
1982-83	10,796	1622	1746	7185	1368	319
1983-84 ^b	10,700	1670	1780	7300	1425	330

^a Data do not include biochemistry and geochemistry. ^b C&EN estimates. Source: Department of Education's National Center for Education Statistics